Компоненты цитоскелета

Cytoskeleton

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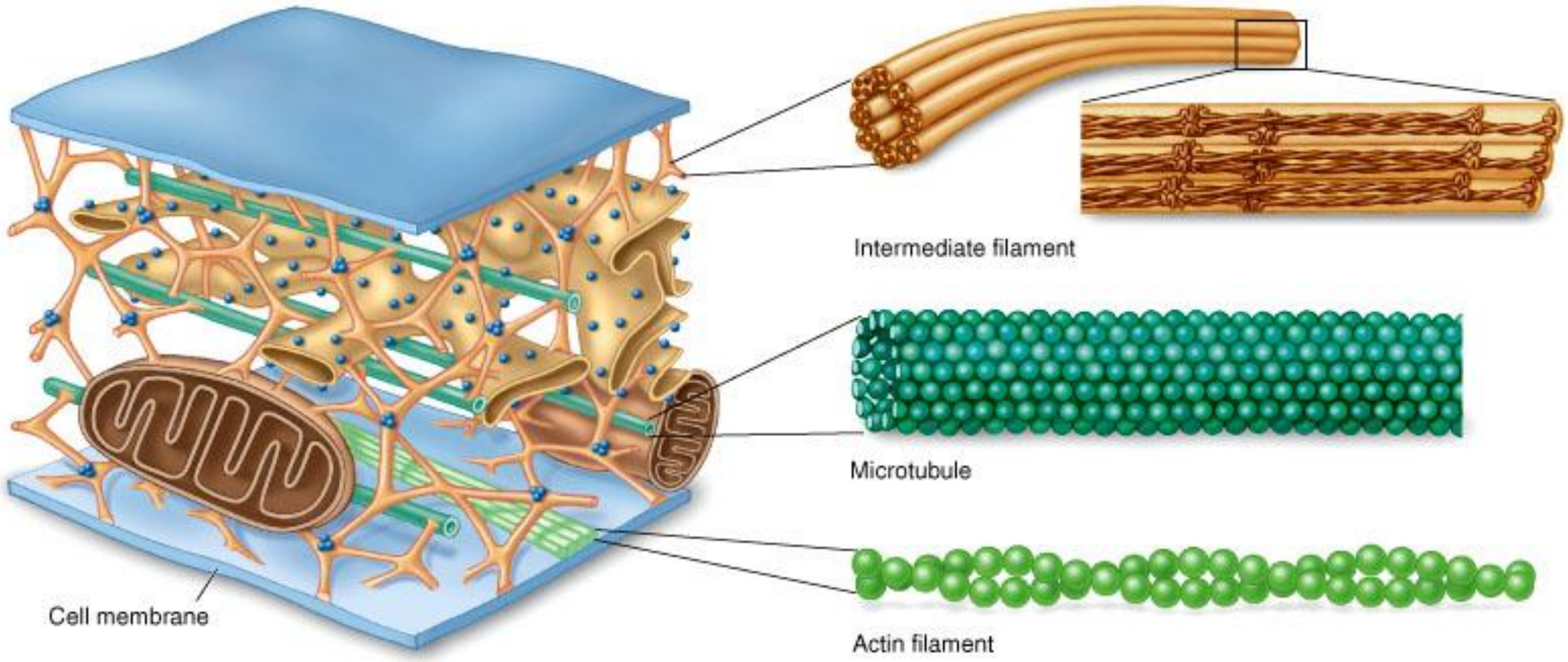

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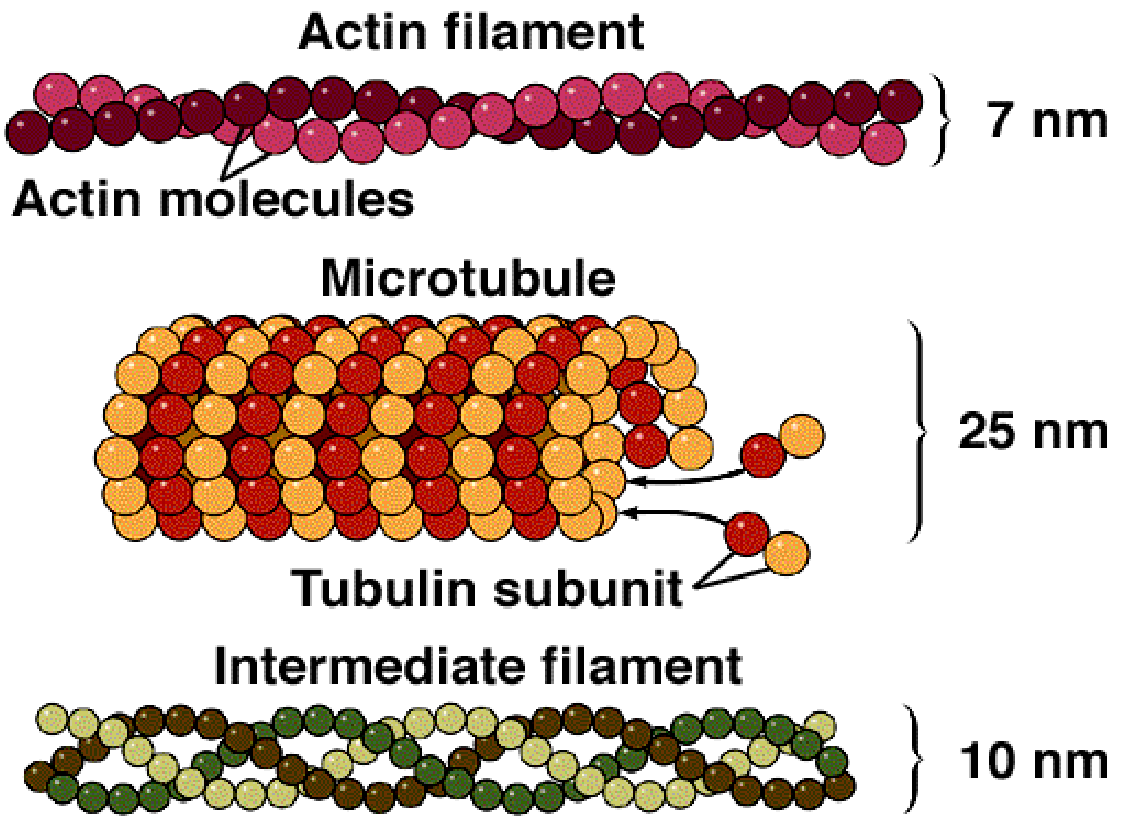
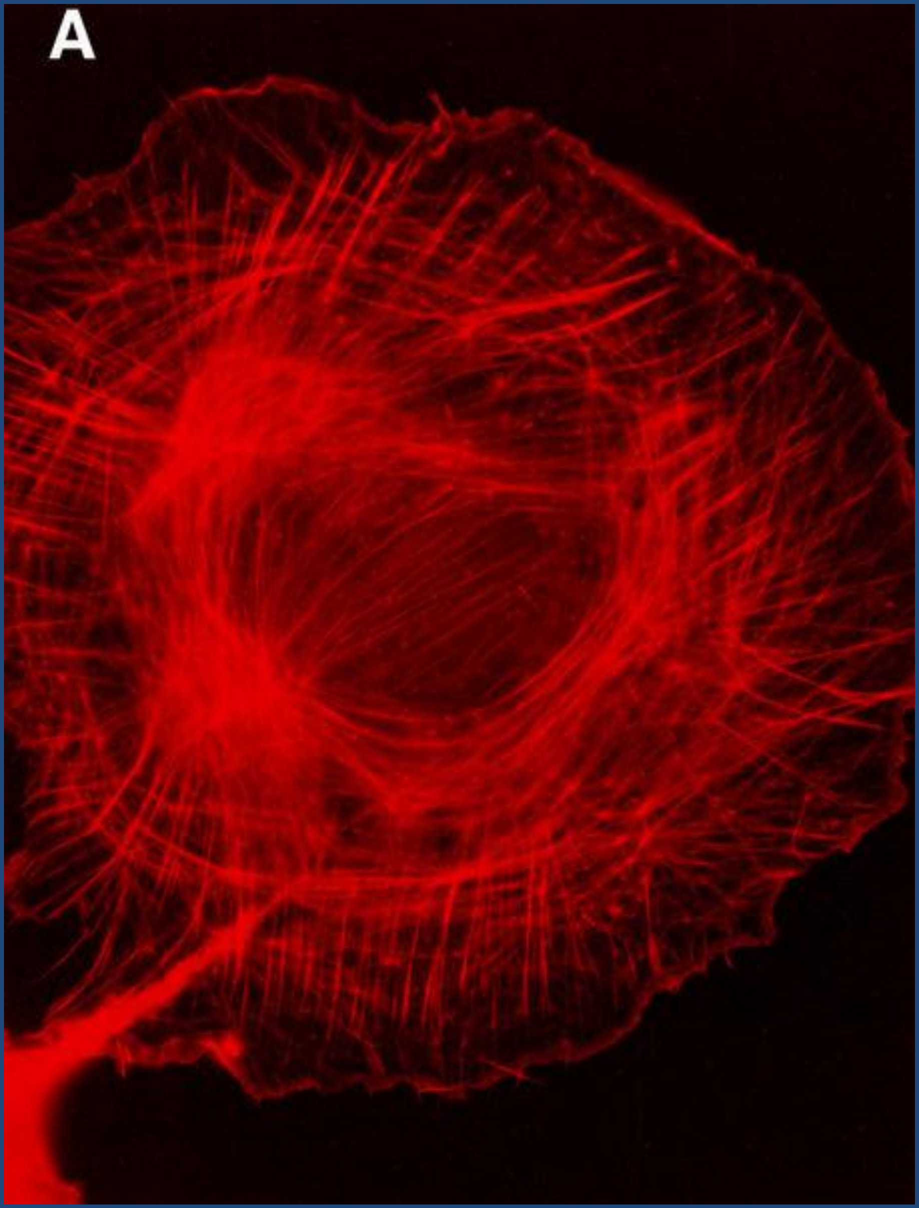
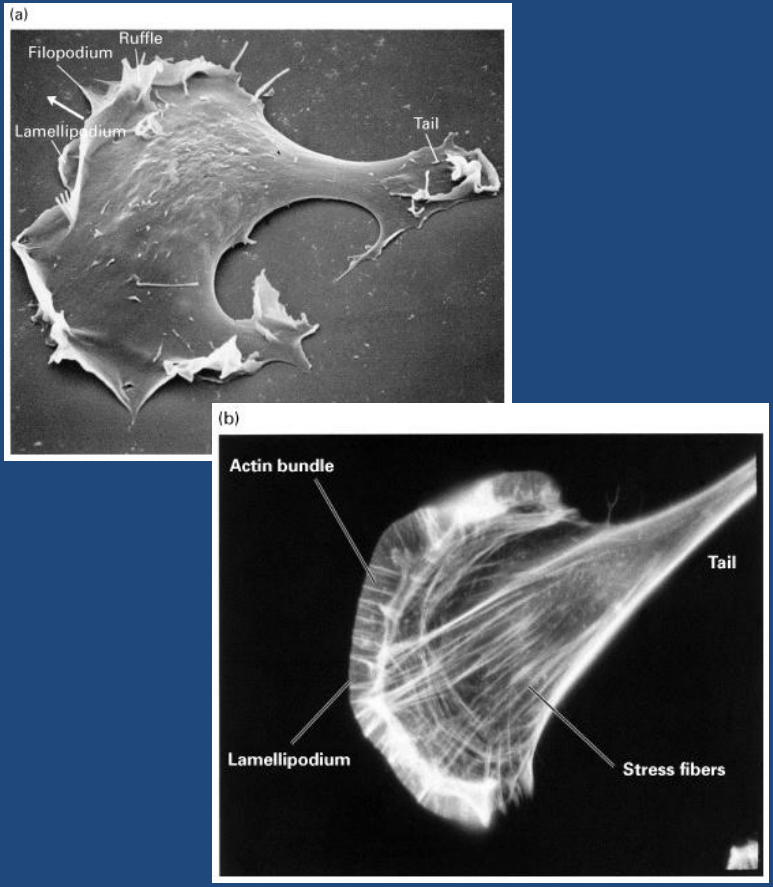
Three Kinds of Cytoskeletal Filaments



The three polymer systems of a fibroblast cytoskeleton, as seen in the fluorescence microscope after fixation and labelling with specific probes

A, the actin cytoskeleton, labelled with fluorescent phalloidin

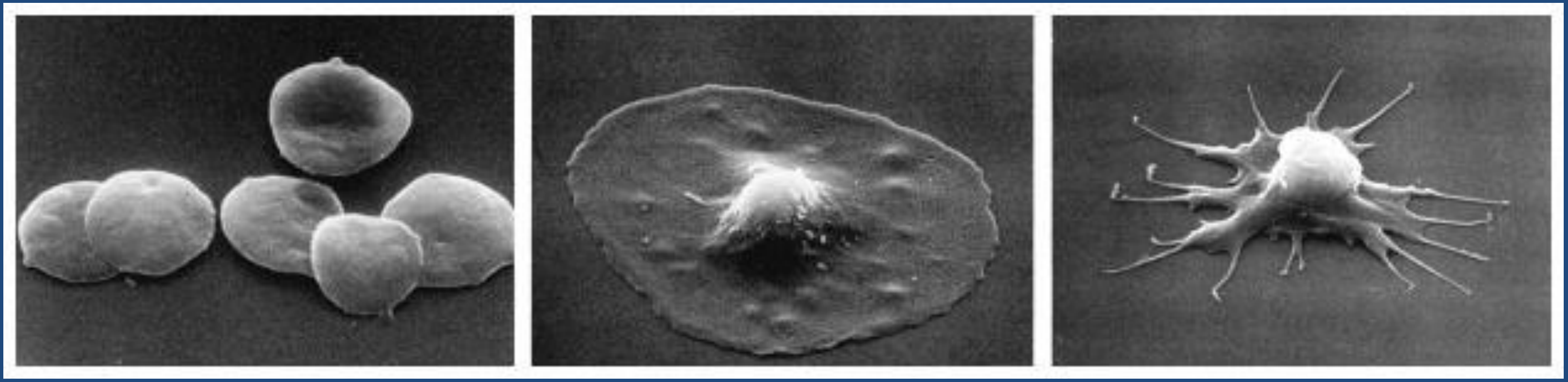




Actin Filaments

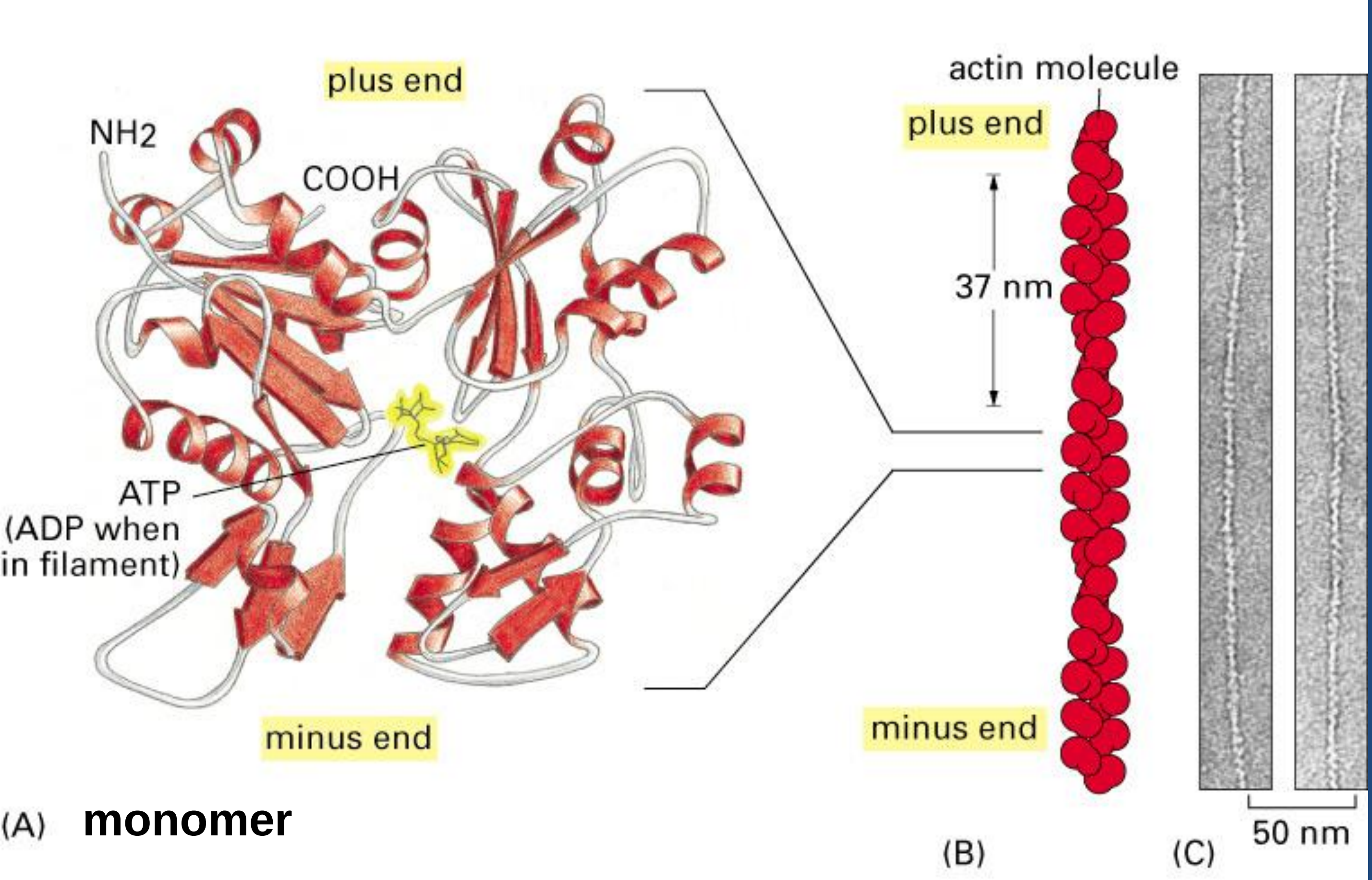
- Also called ***Microfilaments***
- Functions:

1. Movement of cells through ***psuedopodia***
2. ***Muscle contraction*** in multicellular organisms
3. Animal cell division
4. Cell shape



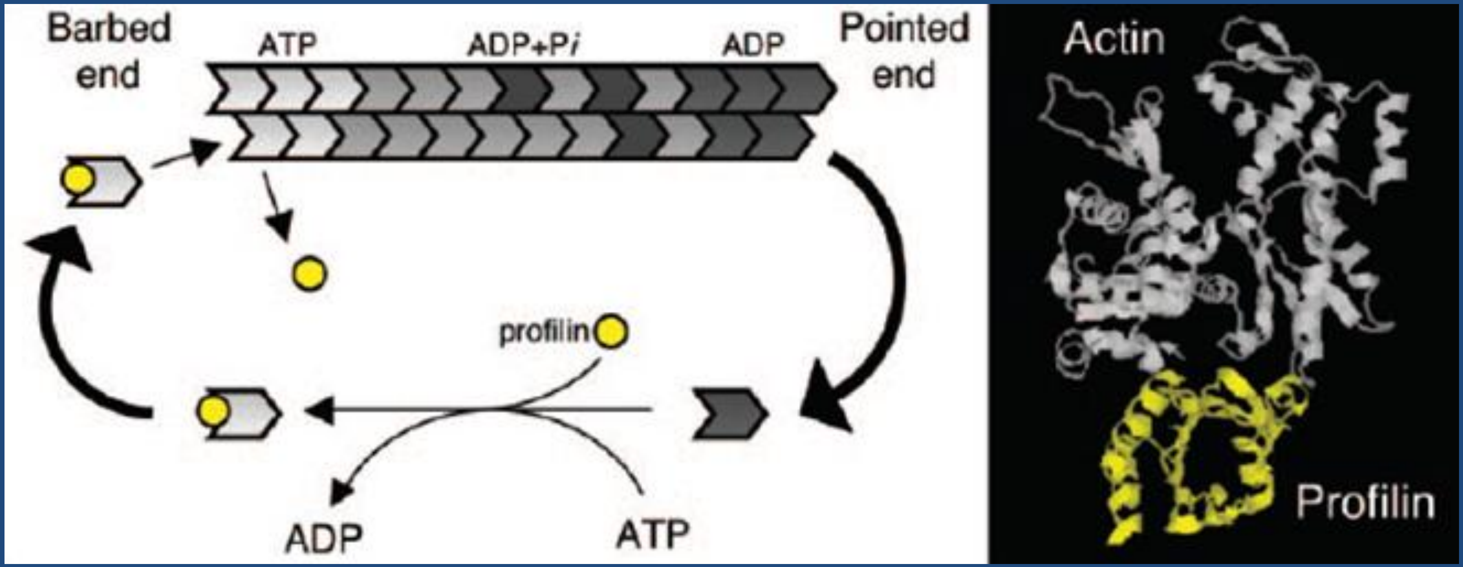
The structure of an actin monomer and actin filament

two parallel protofilaments that twist around each other in a right-handed helix

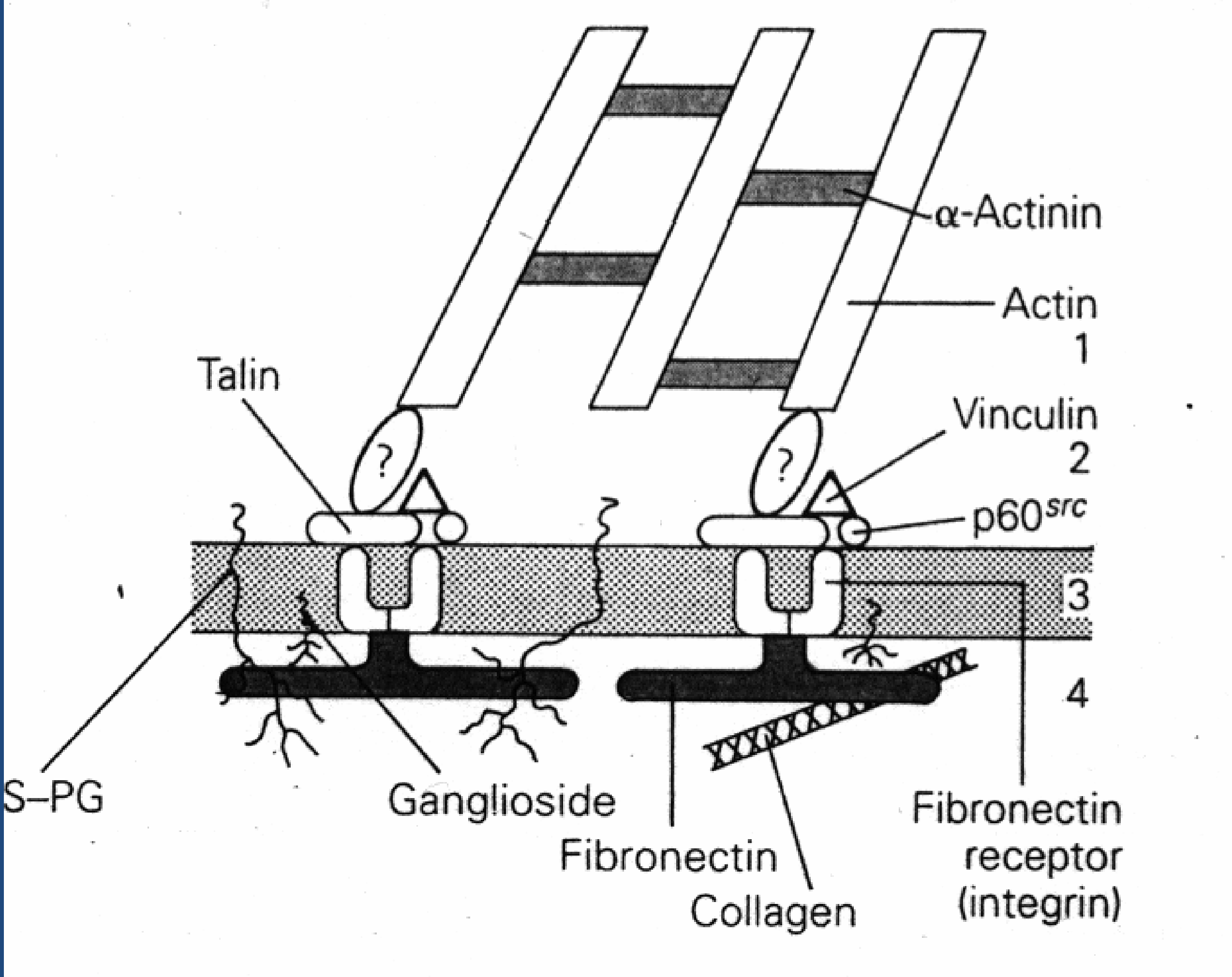


Flexible but cross-linked and bundled together by accessory proteins in a living cell

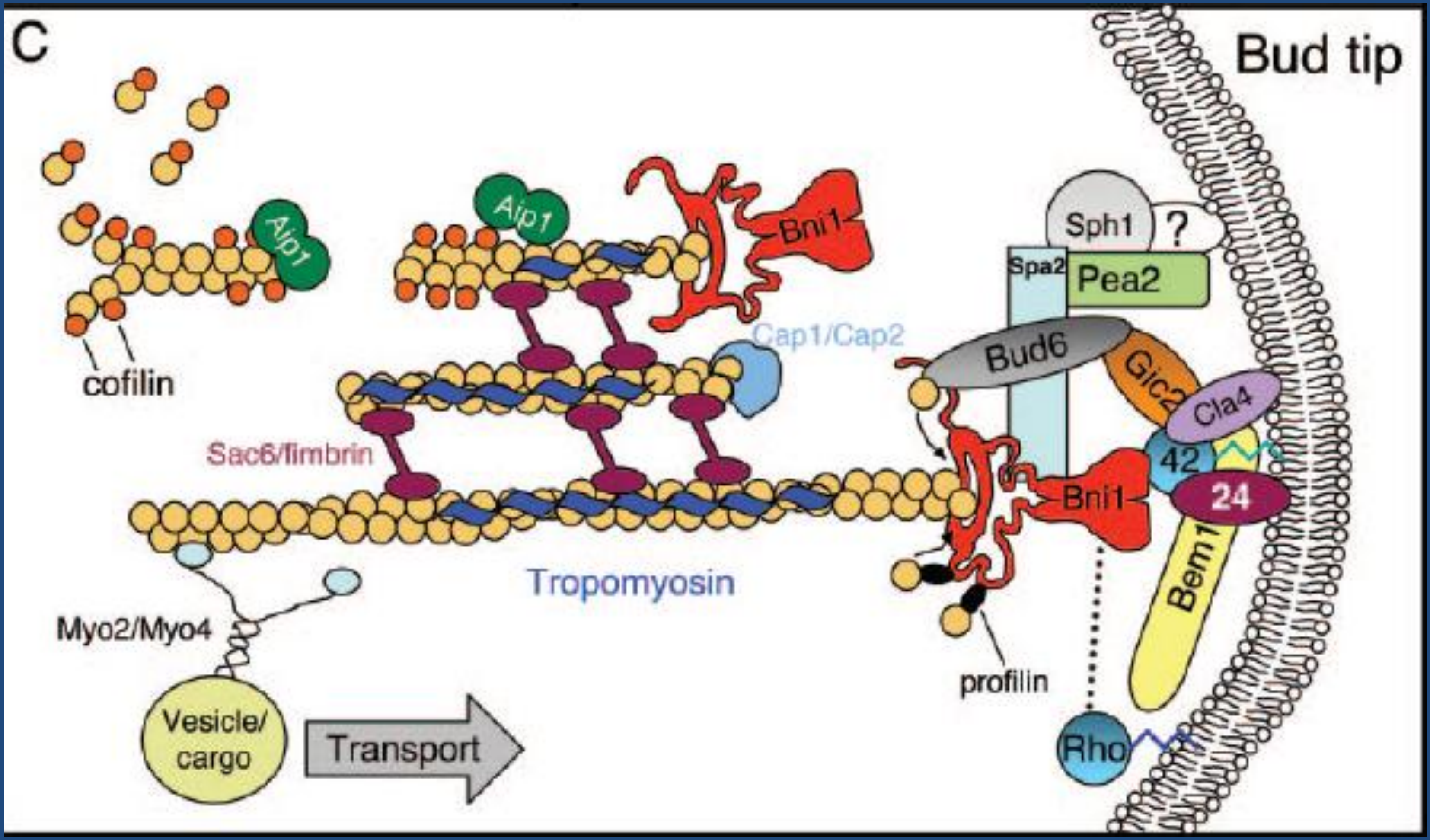
Сборка и цикл обмена актиновых филаментов



Взаимодействие актина с клеточной мембраной и формирование контактов с адгезионными белками внеклеточного матрикса

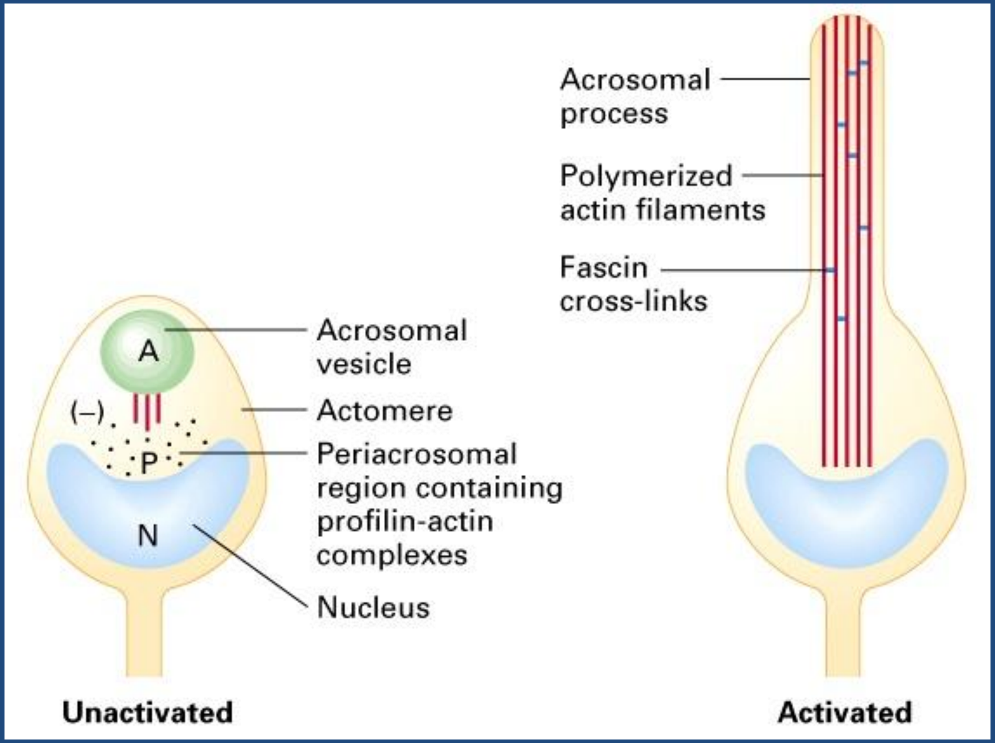


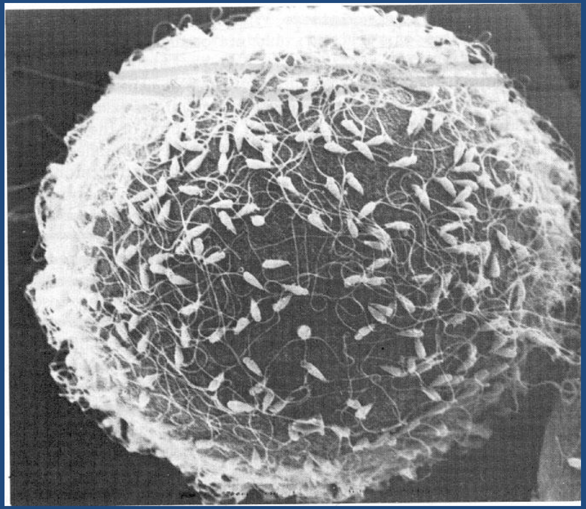
Модель регуляции сборки актинового волокна за счет полярного кэпа на +конце с участием ряда актин-связывающих белков (профилин, кофилин, миозин, кэпирующие белки и т.д)

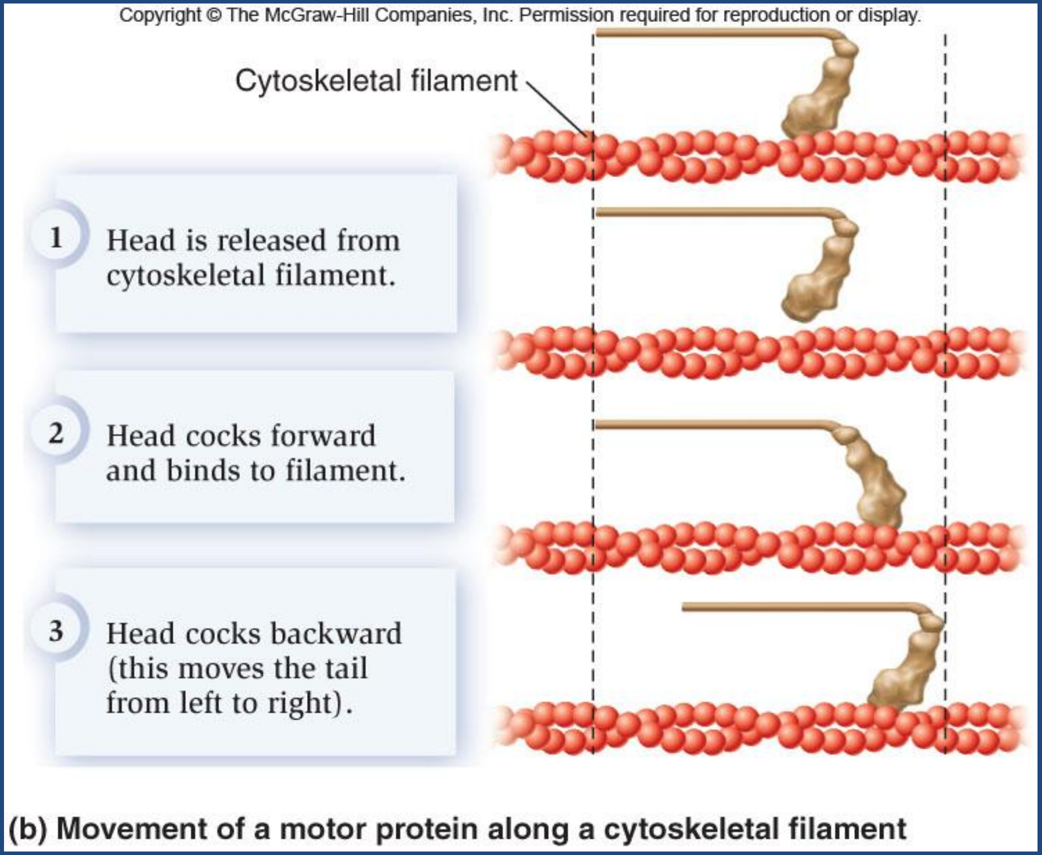


Cell movements driven by microfilaments

- Acrosome reaction: when sperm penetrate the egg cell



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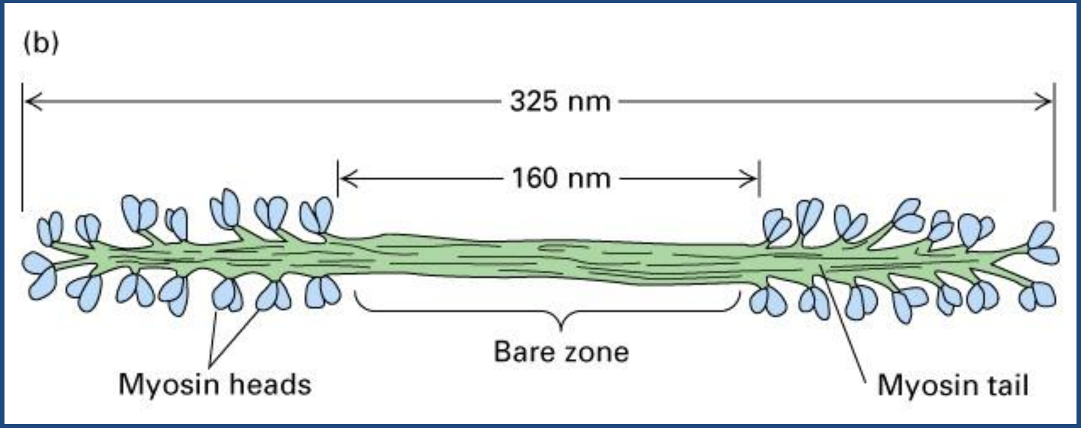
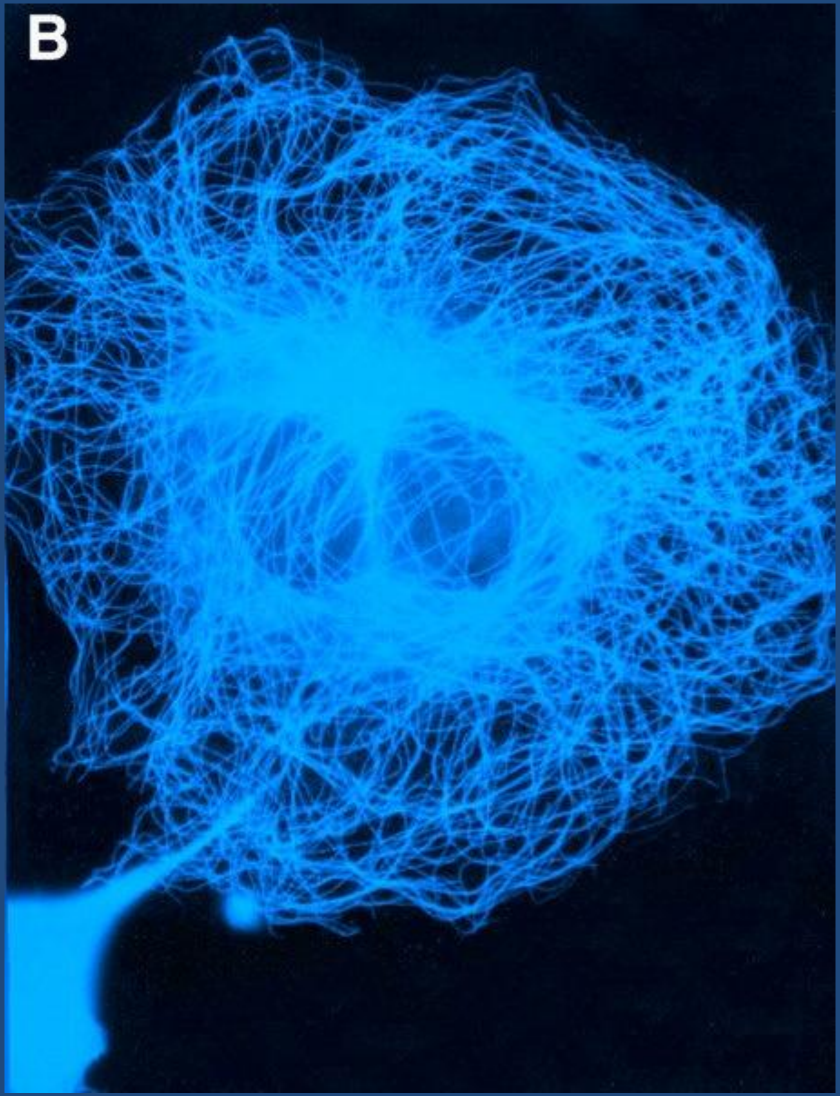
Cytoskeletal filament
1
Head is released from cytoskeletal filament.
2
Head cocks forward and binds to filament.
3
Head cocks backward (this moves the tail from left to right).

(b) Movement of a motor protein along a cytoskeletal filament

- Myosin is an actin motor protein
- Actin & Myosin are responsible for muscle contraction

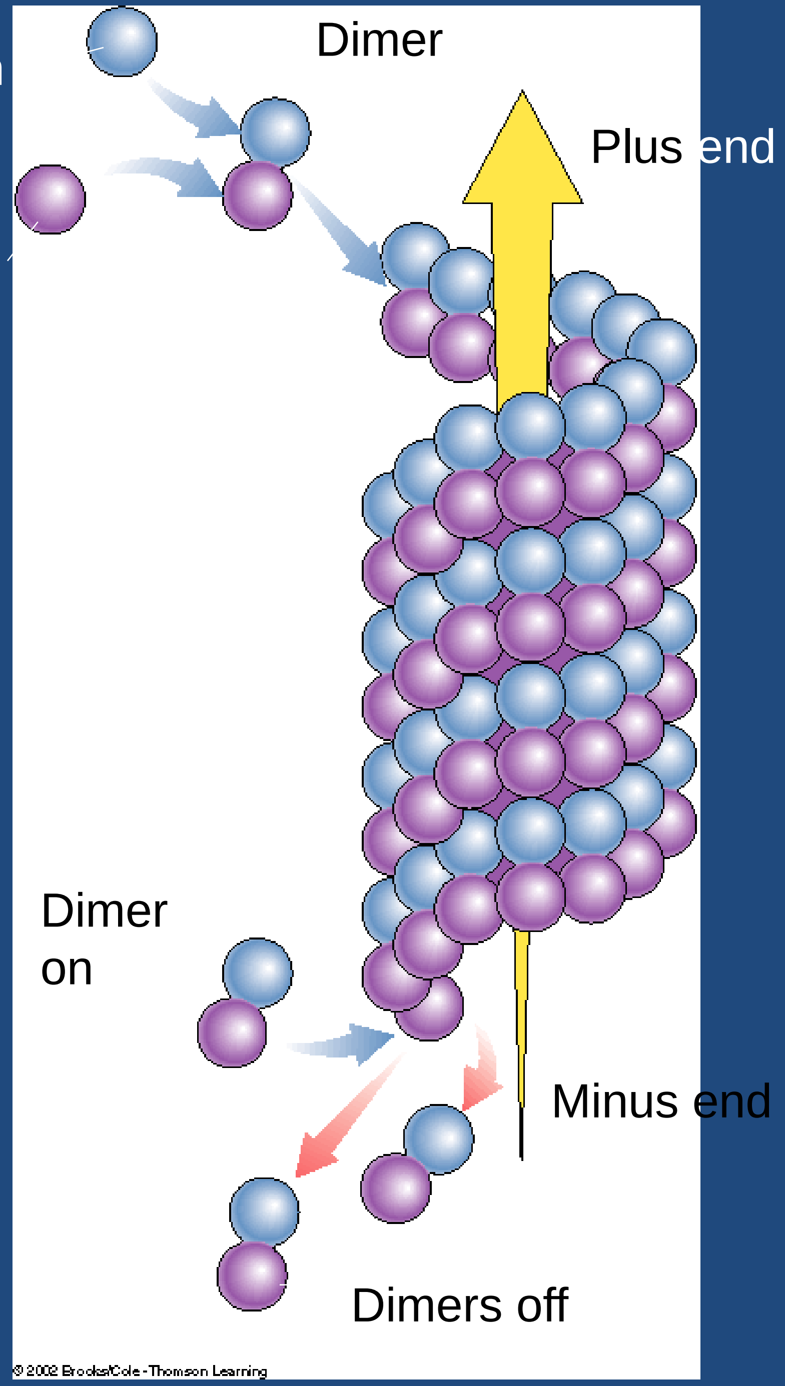




the microtubule cytoskeleton labelled with an antibody to tubulin

Microtubules

- Thickest filaments of the cytoskeleton
- Function in:
  1. Mvmt of chromosomes
  2. Mvmt of organelles
  3. Mvmt of cargo (vesicles)
  4. Cell motility (cilia and flagella)
  5. Cell shape
- Made of two proteins that form dimers
  1. α-tubulin
  2. β-tubulin



(a)

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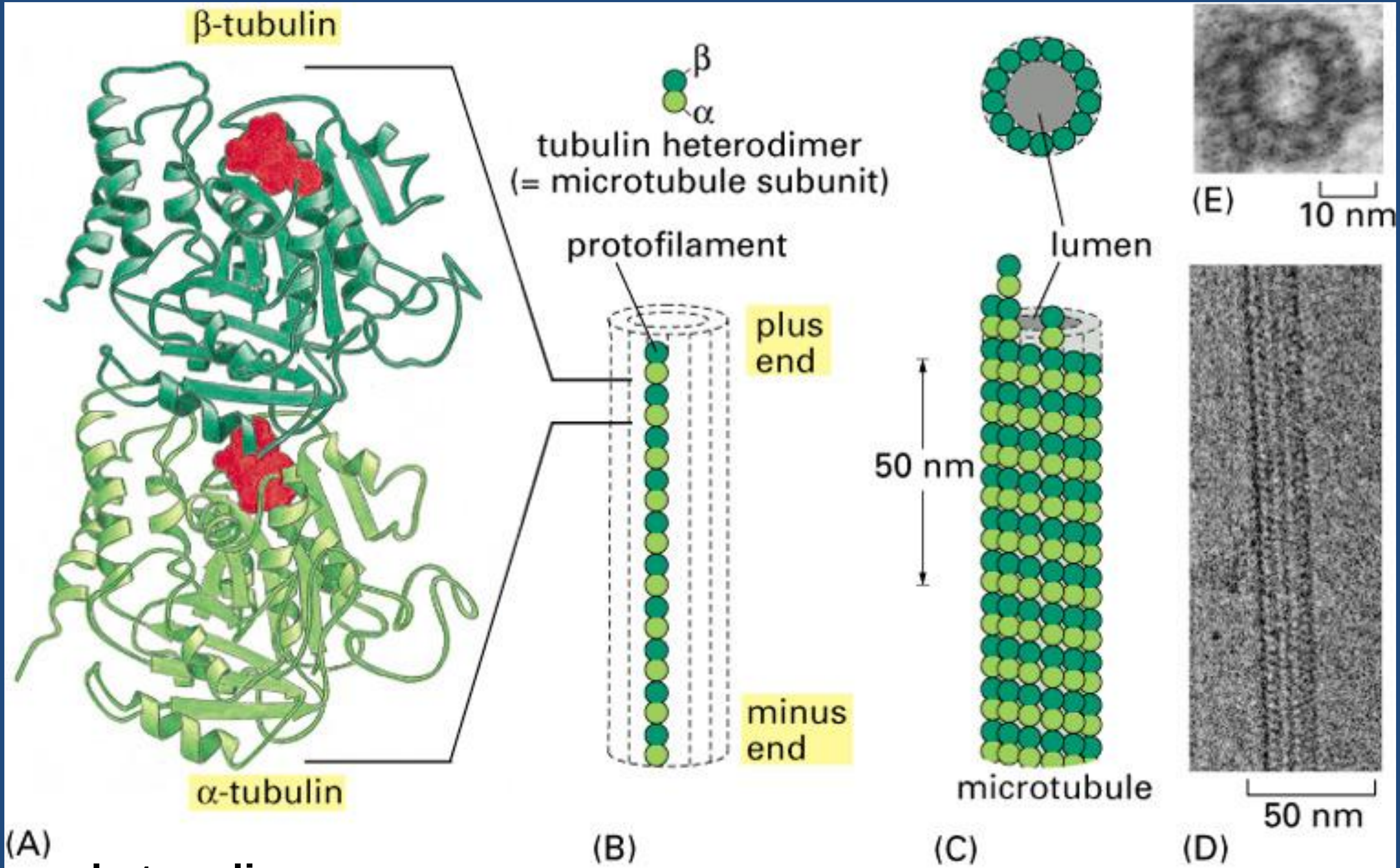
The structure of a microtubule and its subunits

GTP

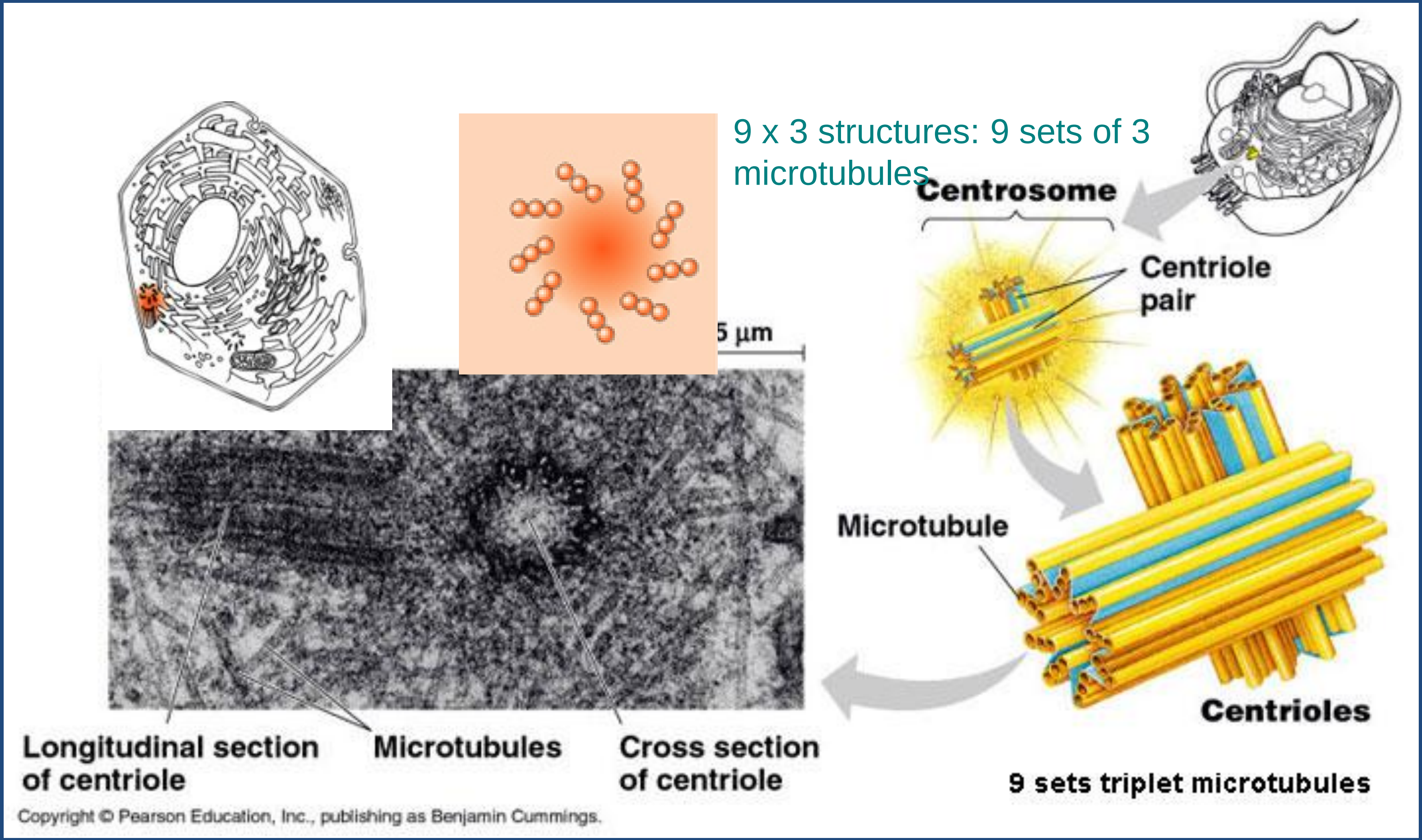
GTP



heterodimer

13 parallel protofilaments

hollow and cylindrica and polar



9 x 3 structures: 9 sets of 3 microtubules

Centrosome
Centriole pair
Microtubule
Centrioles
9 sets triplet microtubules
5 µm
Longitudinal section of centriole
Microtubules
Cross section of centriole

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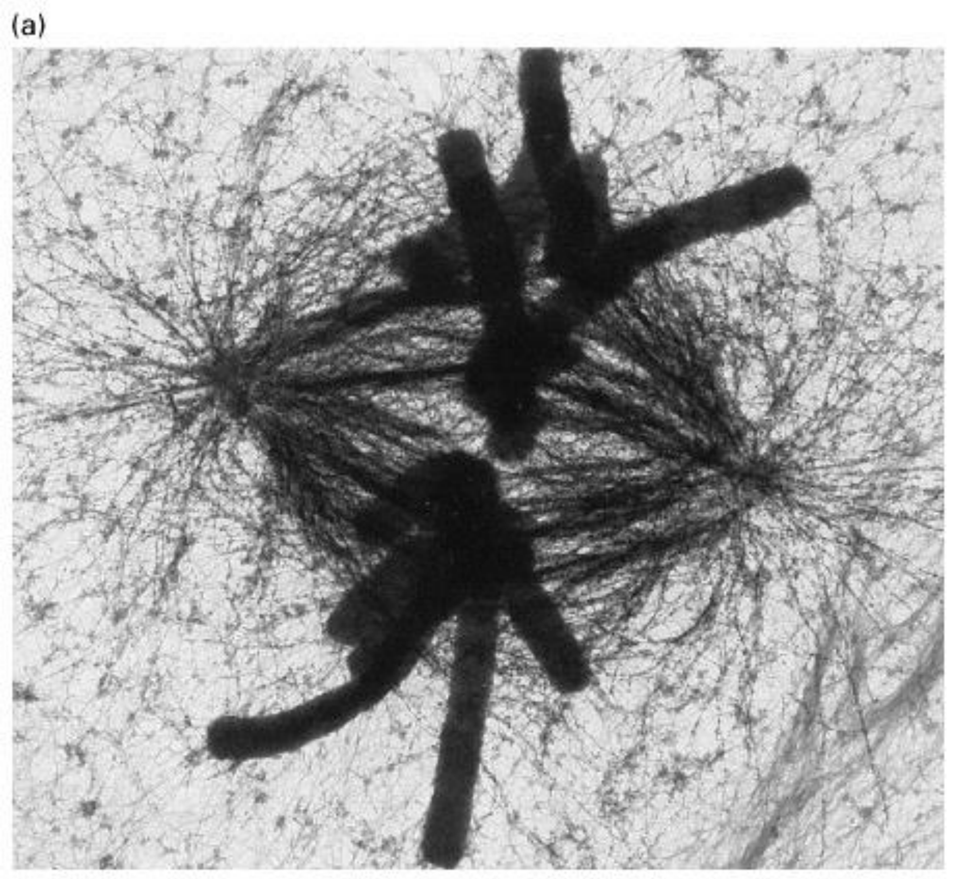
- Microtubules must be anchored to some part of the cell
- Centrosome or Microtubule organizing centers (MTOCs)
  - **basal bodies** are important in cilia and flagella
  - **centrioles** are important in cell division

Mitosis and Microtubule Movement of Chromosomes

During mitosis, the **centrioles** anchor the formation of microtubules which form the spindle on which the chromosomes will attach.



Клетки с нецентросомными «лучами» микротрубочек

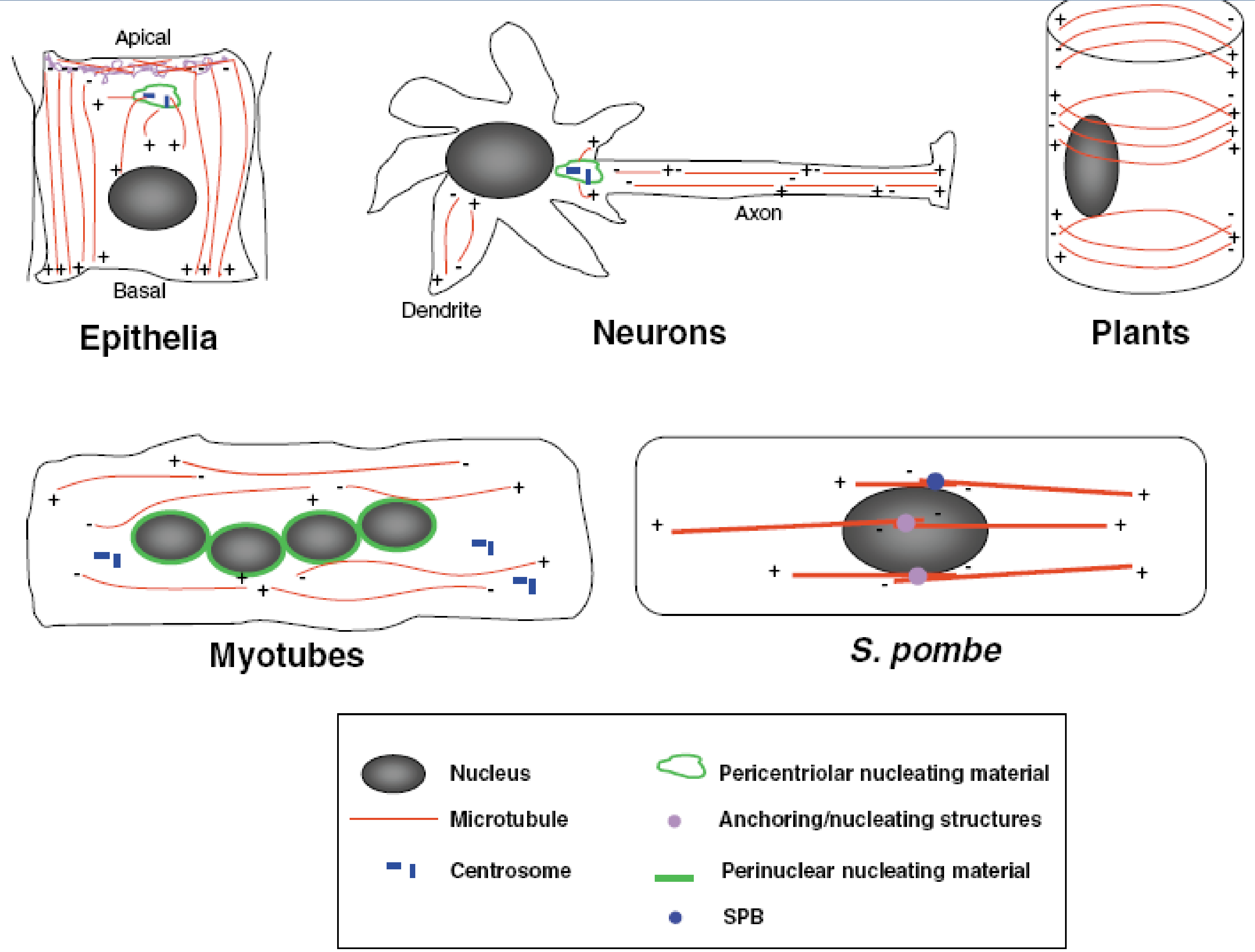

Apical
Basal
Epithelia
Dendrite
Axon
Neurons
Plants
Myotubes
S. pombe
Nucleus
Microtubule
Centrosome
Pericentriolar nucleating material
Anchoring/nucleating structures
Perinuclear nucleating material
SPB

Fig. 1. Cells with noncentrosomal MT arrays.

3-х-ступенчатая гипотеза появления нецентросомных МТ

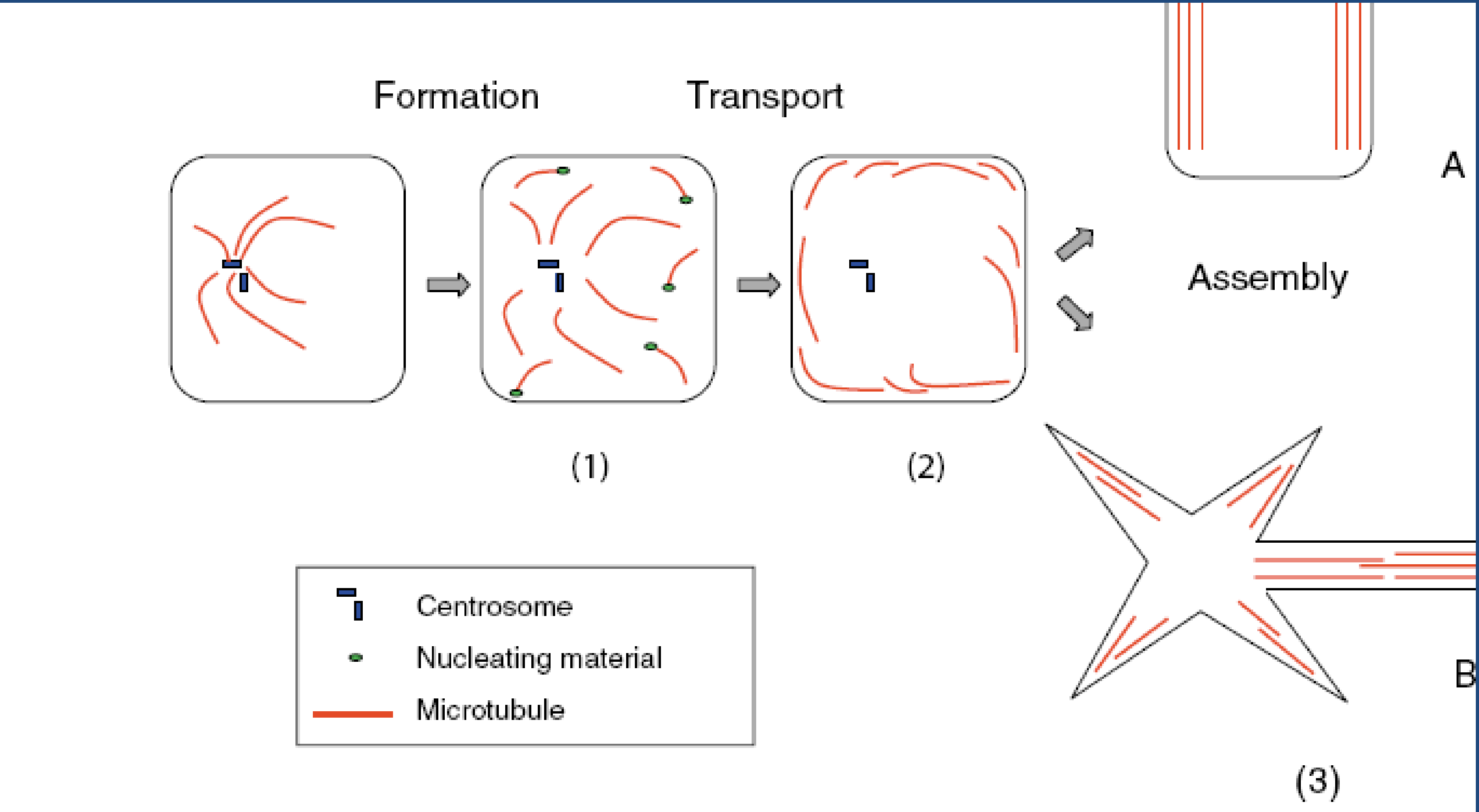
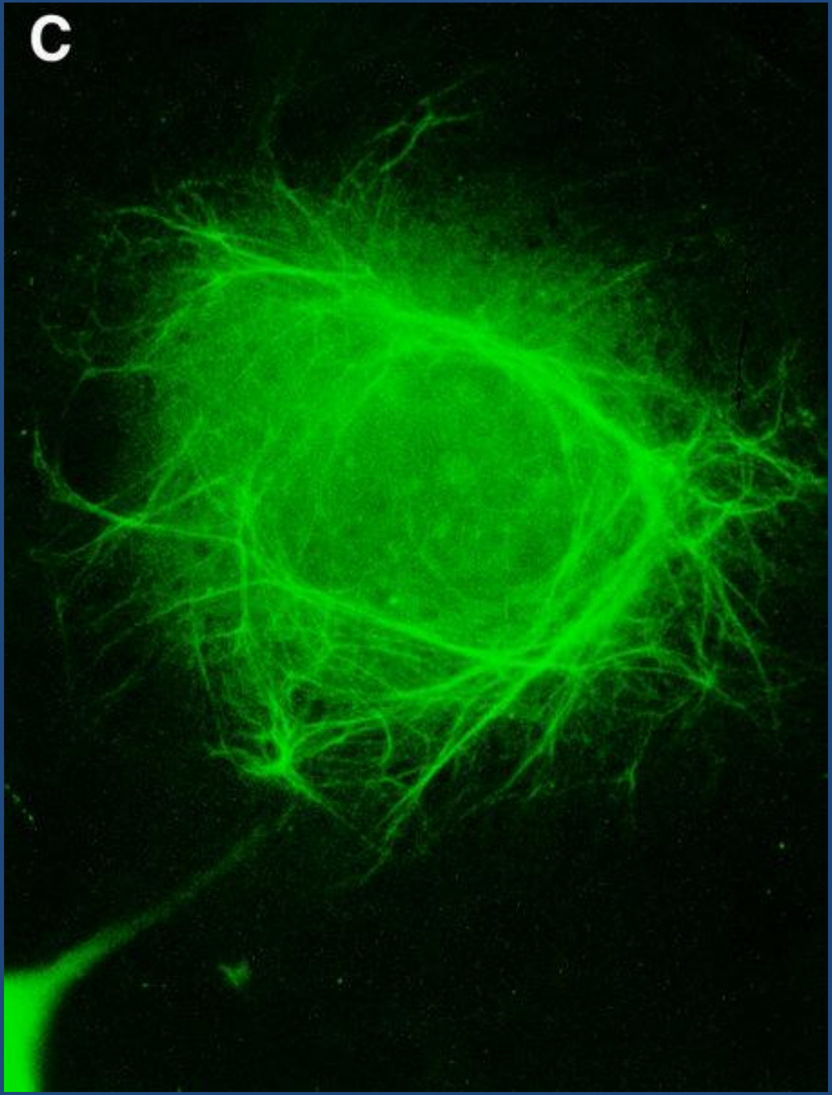


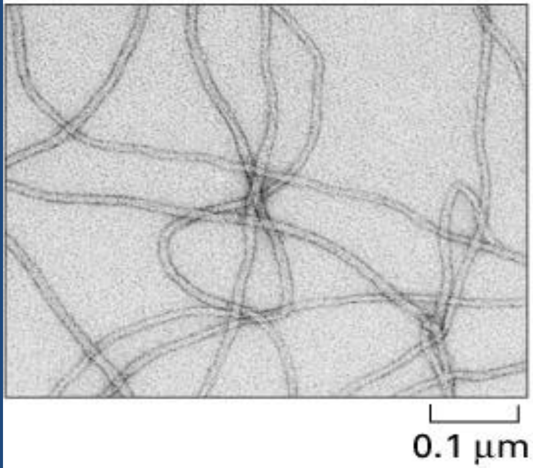
Fig. 2. The three-step hypothesis. Schematic diagram of the three steps in the formation of noncentrosomal MT arrays.

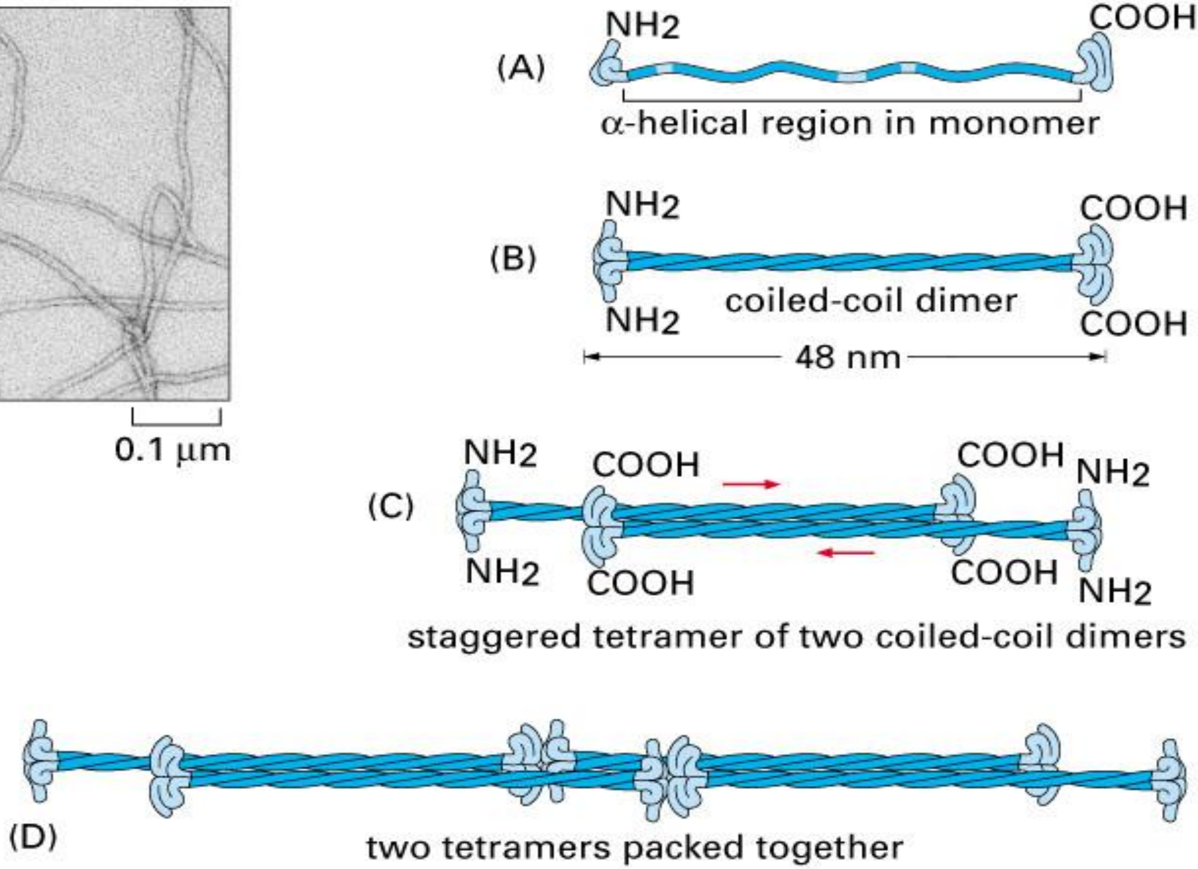
Промежуточные филаменты

the intermediate filament cytoskeleton labelled with antibodies to the intermediate filament protein, vimentin



A model of intermediate filament construction



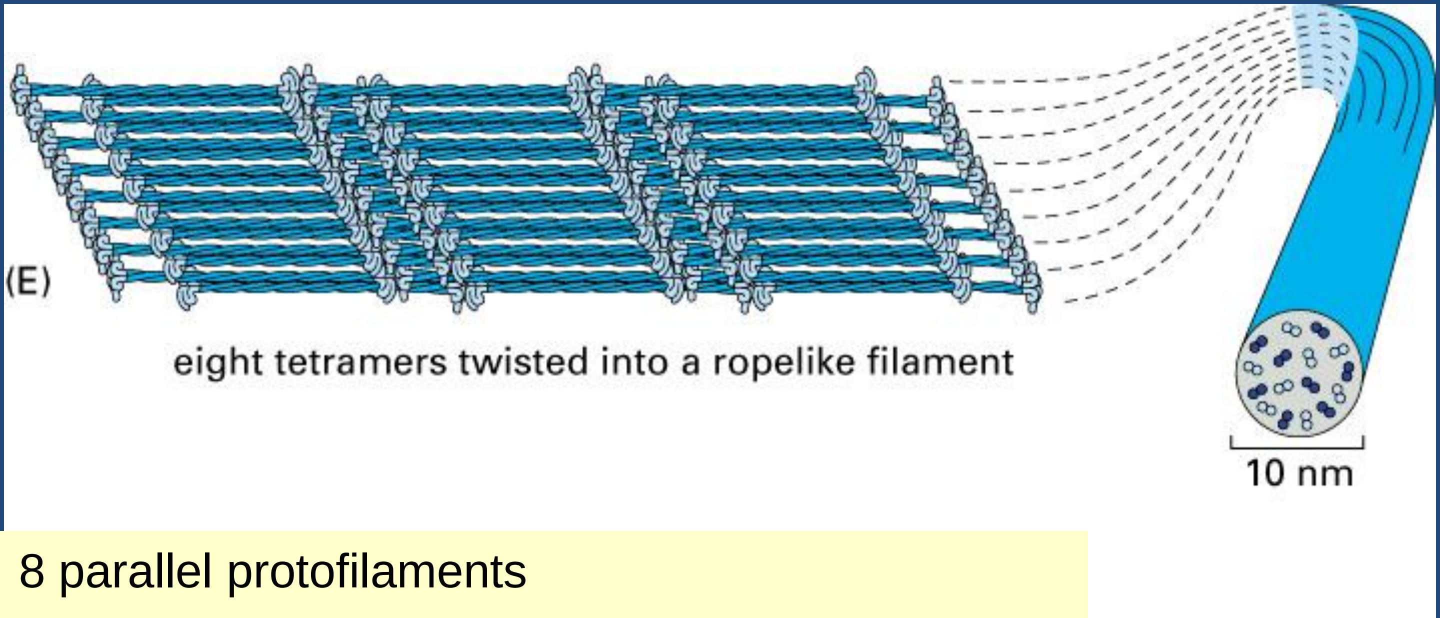

(A)
NH2
COOH
α-helical region in monomer
(B)
NH2
COOH
NH2
coiled-coil dimer
COOH
48 nm
(C)
NH2
COOH
COOH
NH2
NH2
COOH
COOH
NH2
staggered tetramer of two coiled-coil dimers
(D)
two tetramers packed together

No polarity!

Intermediate filaments are only found in some metazoans: vertebrates, nematodes, molluscs. Not required in every cell type
Ancesters: nuclear lamins. Easily bent, Hard to break

Intermediate Filaments

- IF function is structural: to reinforce cells and organize them into tissues
  - Claws and hair are the dead remnants of epidermal cells composed mainly of IF proteins
  - Function in the Extra Cellular Matrix to bind cells into tissues
  - Motility is NOT a function



8 parallel protofilaments

Промежуточные филаменты: динамика

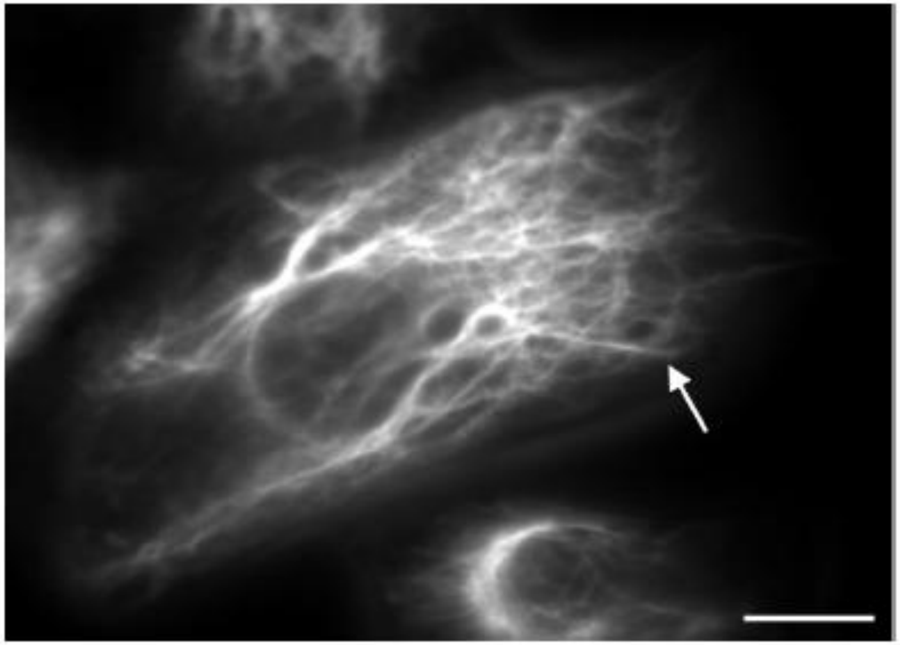


Figure 1. Movie 1: The IF array is dynamic. Shown is the behavior of the IF array in an NIH3T3 cell expressing GFP-vimentin. The movements of the IF array in this movie are typical of other arrays we have recorded. Bar, 15 μm.

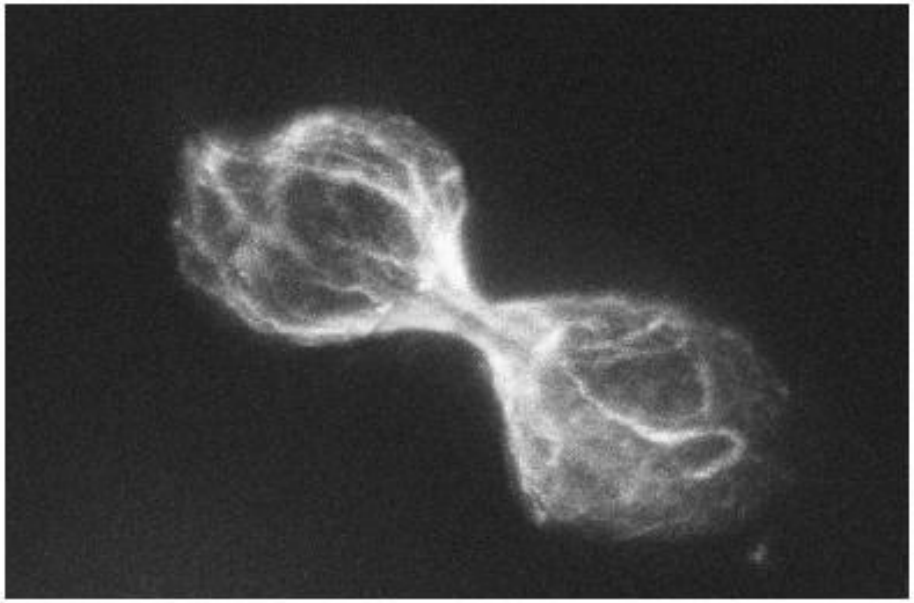
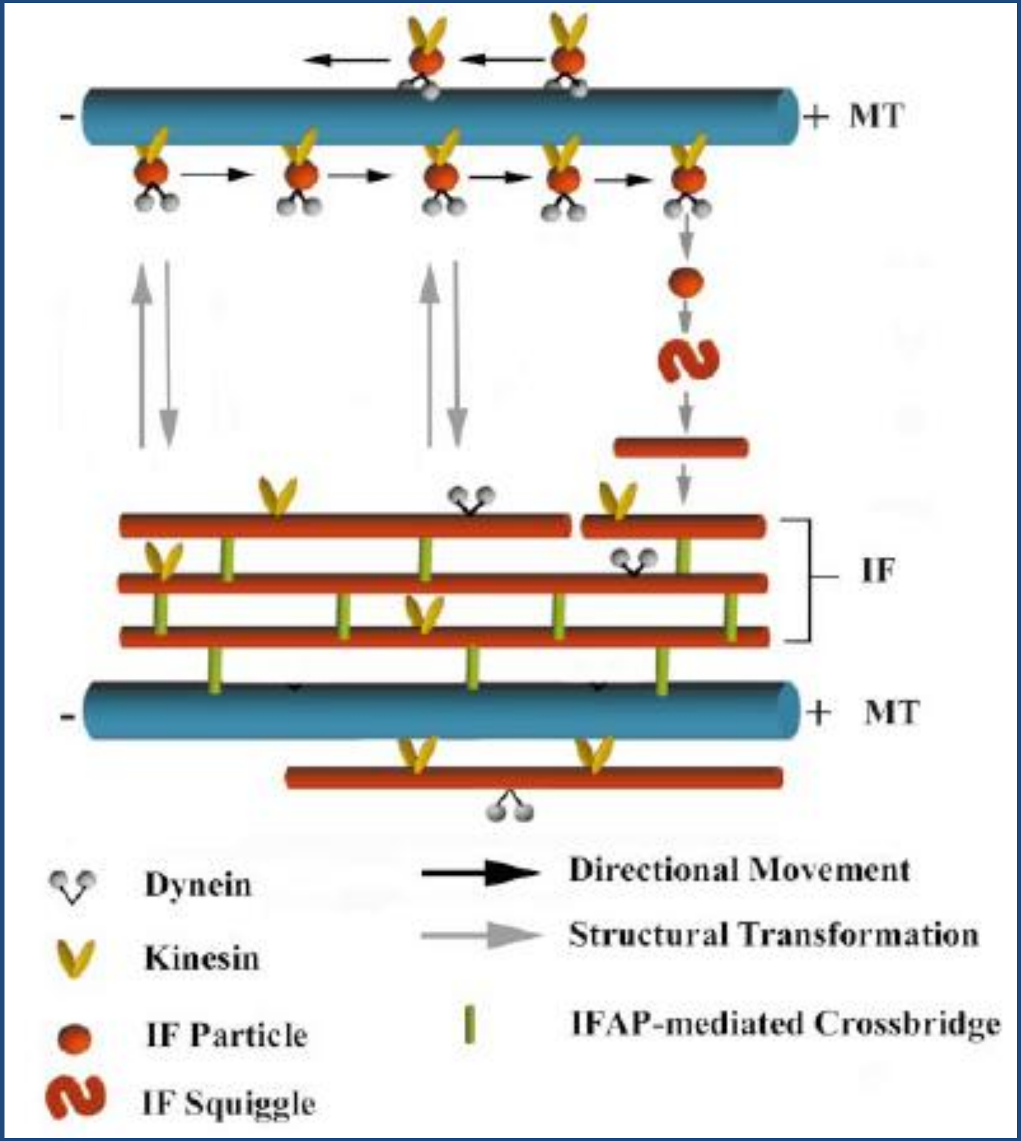
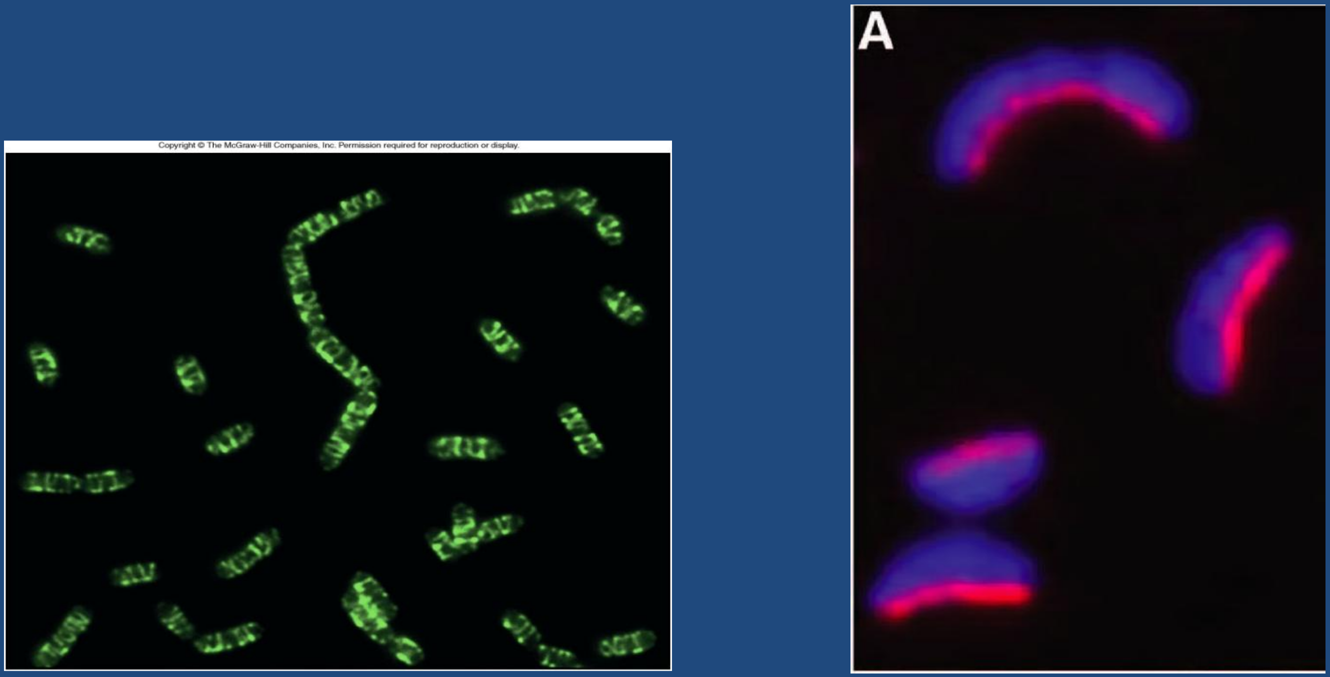


Figure 2. Movie 2: IFs in a mitotic cell form cage-like structures around dividing nuclei. The organization of GFP-vimentin in a dividing NIH3T3 cell is shown. The IF array forms cage-like structures around the daughter nuclei, and it is connected by a bridge.



- Гипотетический механизм , объясняющий динамические свойства интерфазных промежуточных филаментов:
- взаимные превращения *длинных и коротких филаментов и нефиламентных олигомеров* с участием микротрубочек как направляющих структур и
- дальнейшее сшивание МТ и IF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Цитоскелетные структуры прокариот

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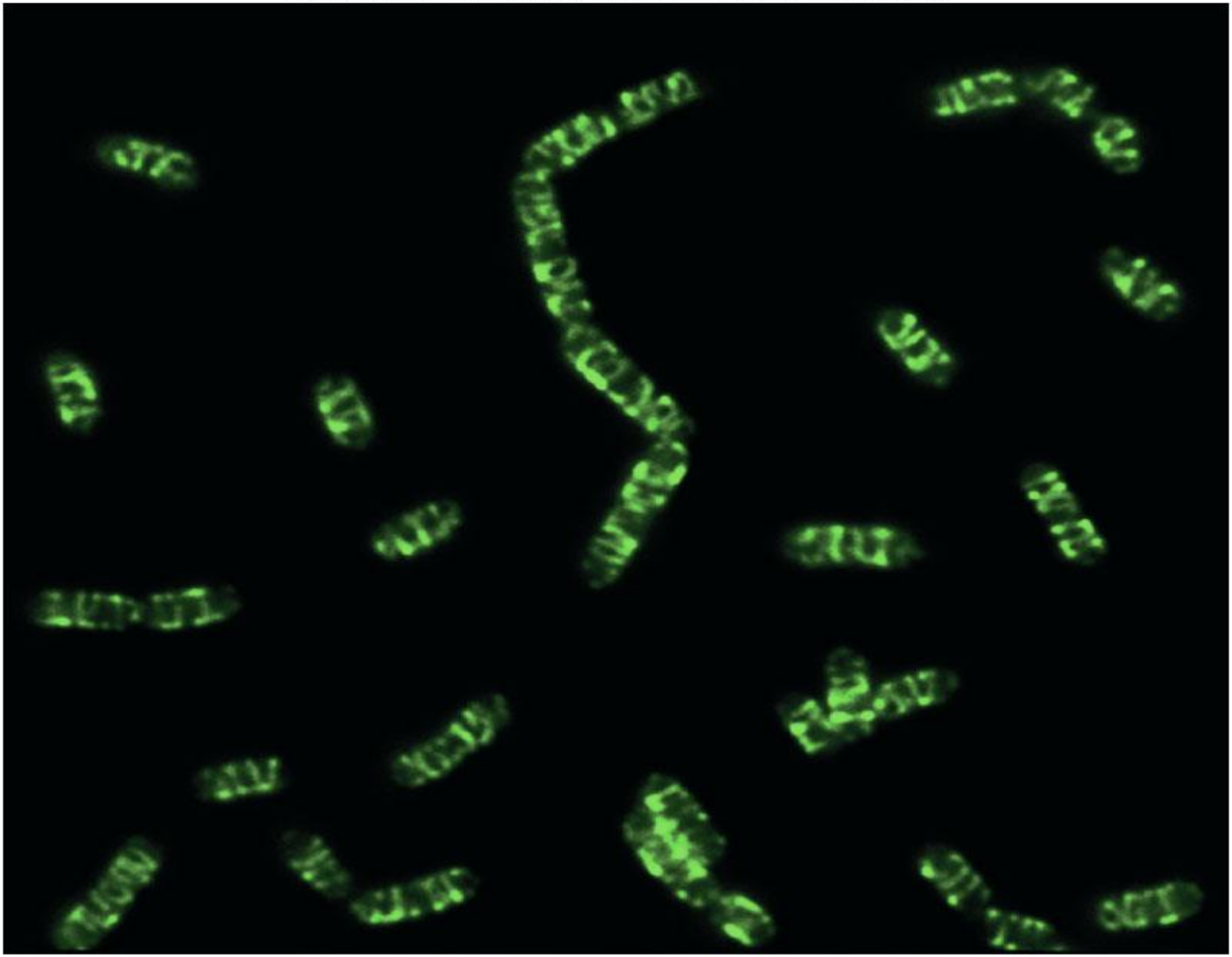
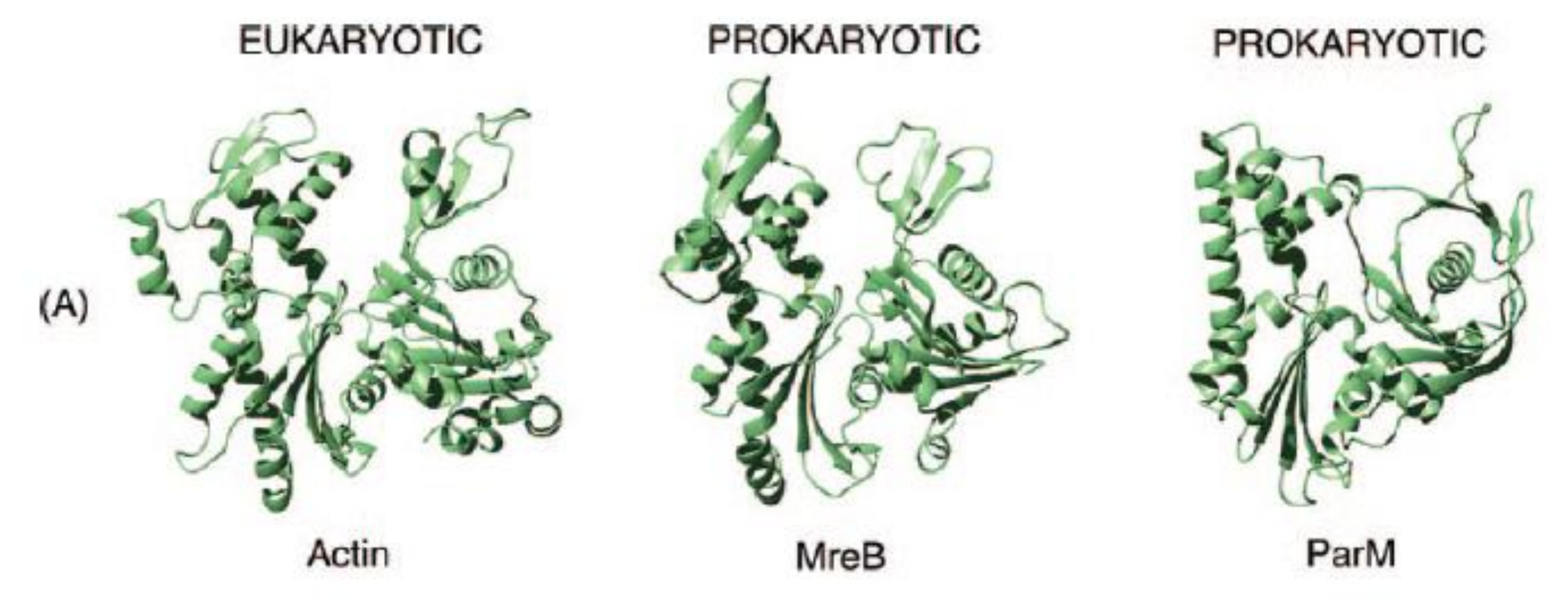


Actin is a protein fiber present in some bacteria, which is involved in maintaining cell shape.

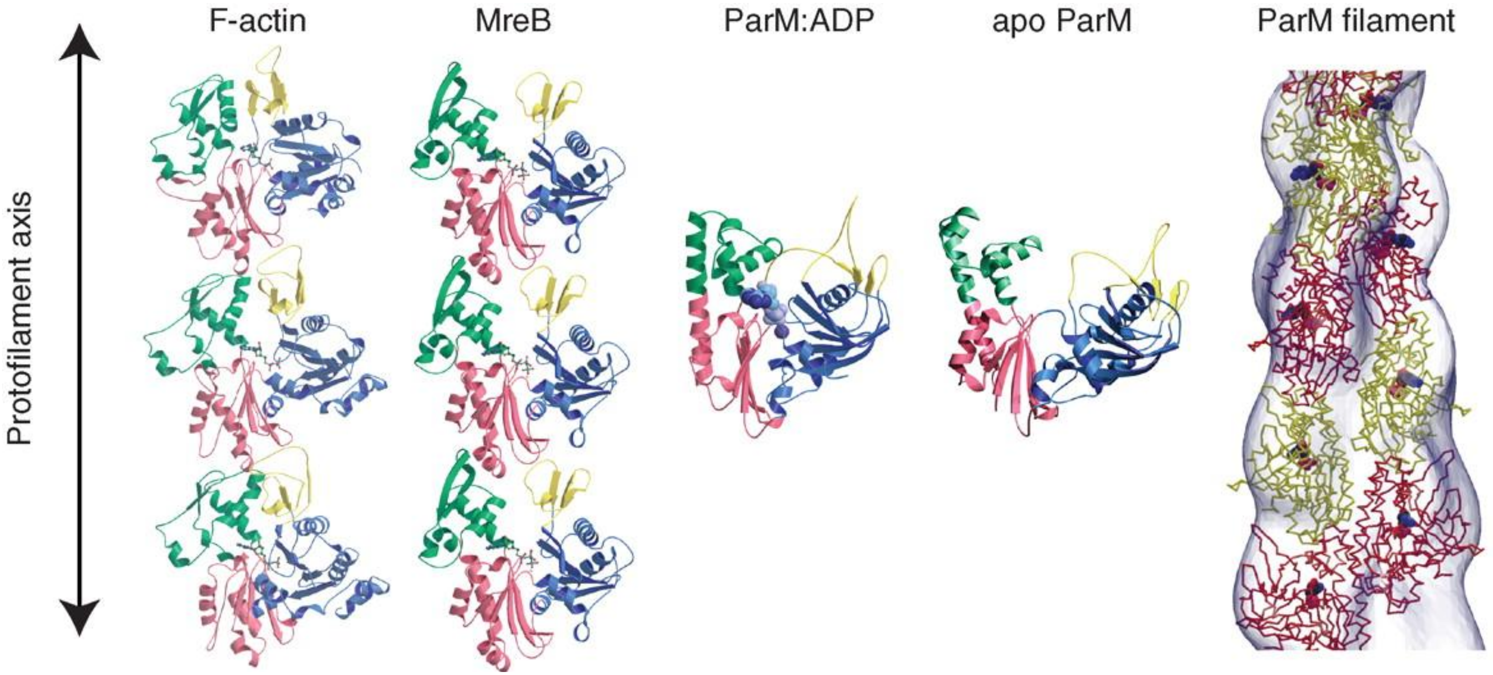
Прокариотические гомологи актина

From left to right:

- *Saccharomyces cerevisiae* actin, ATP bound
- *Thermotoga maritima* MreB, AMPPNP bound
- ParM of plasmid R1, ADP bound



Structures of F-actin (Holmes et al. 1990), MreB (van den Ent et al. 2001), and ParM (van den Ent et al. 2002).



Shaevitz J W , and Gitai Z Cold Spring Harb Perspect Biol 2010;2:a000364

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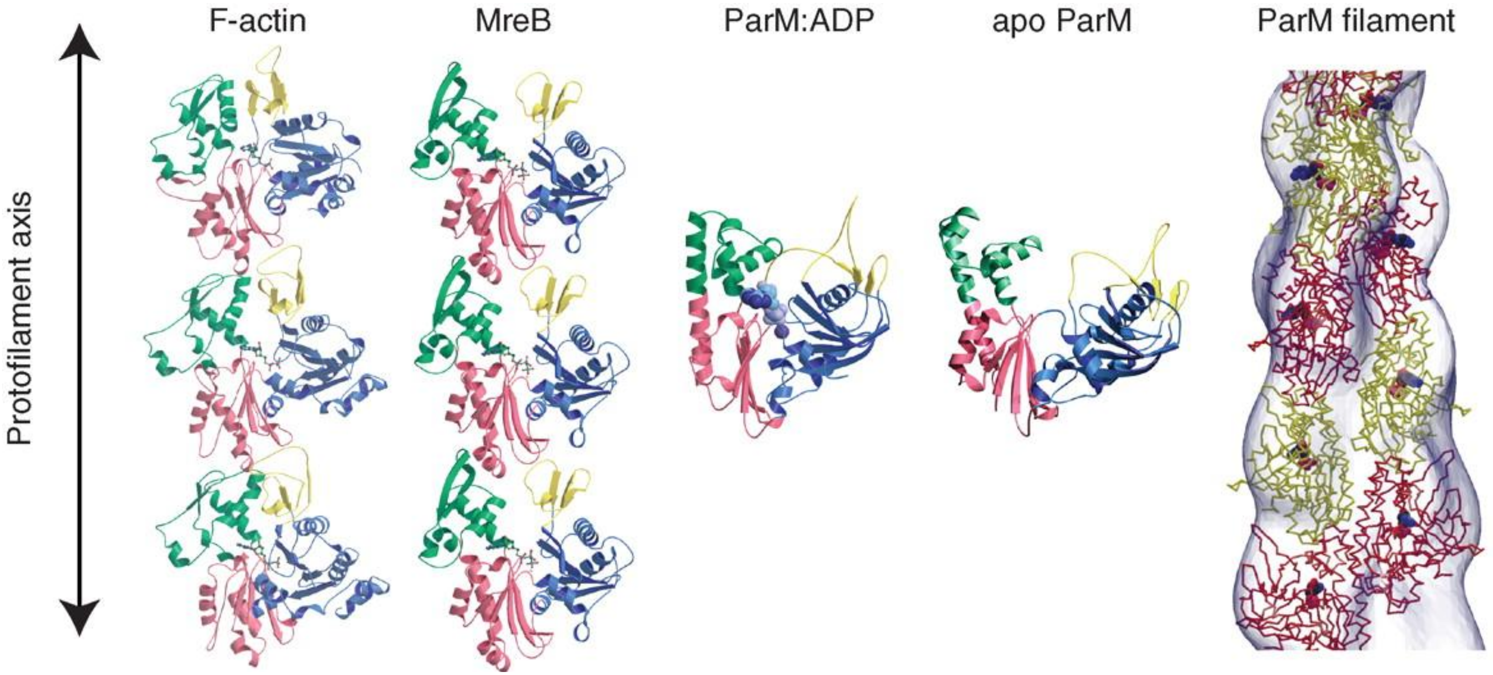

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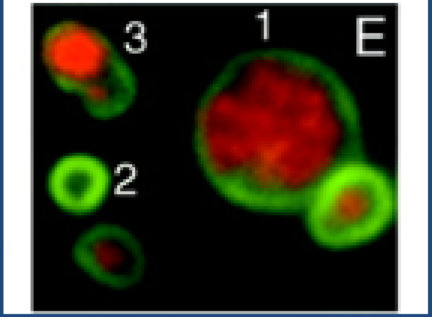
Localization and functions of the actin-like MreB protein

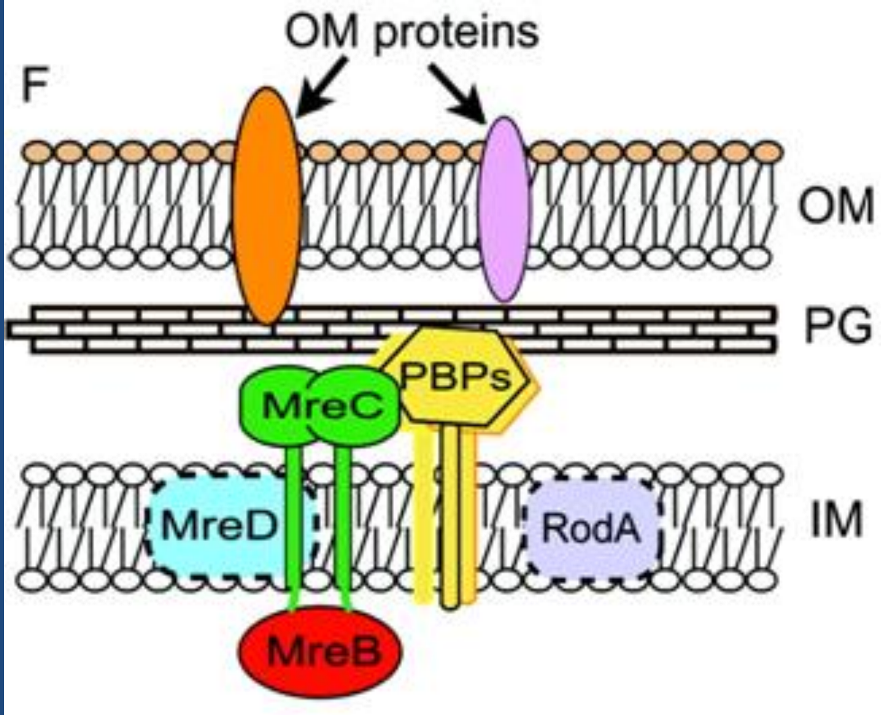


(E) Chromosome segregation in *E. coli* *mreB* deletion strain
Bacterial DNA – red /membrane - green

(F) Suggested organization of cytoskeleton-associated cell wall-synthesizing proteins of *E. coli*.

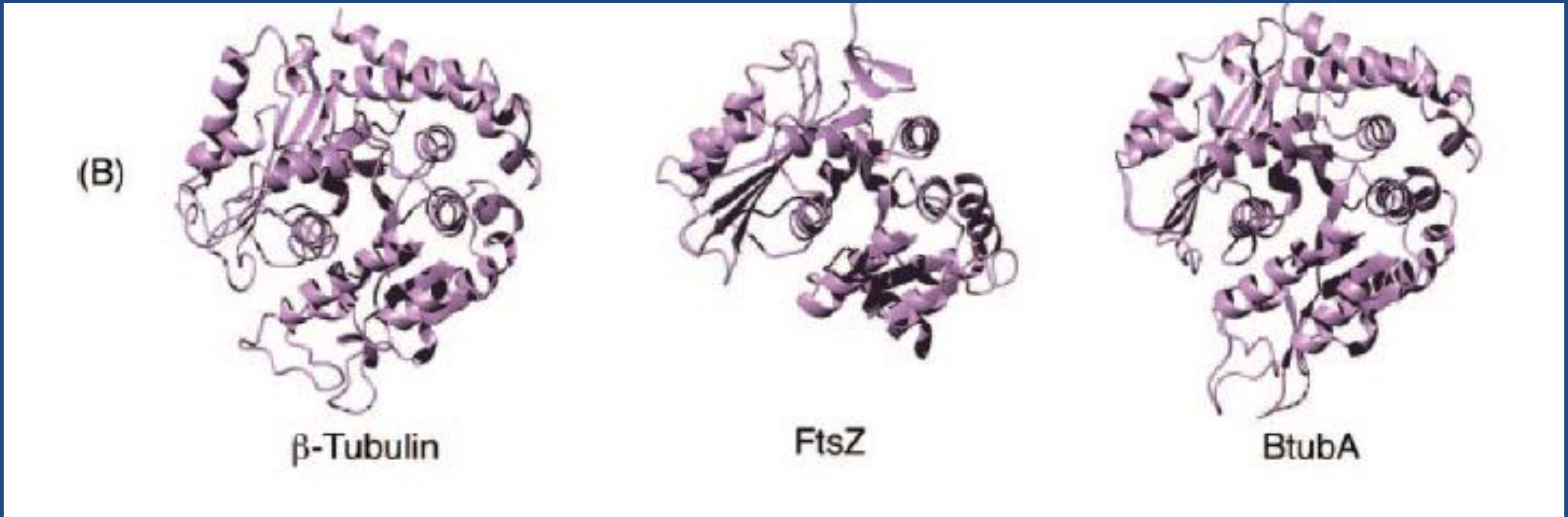
The cytoplasmic MreB cytoskeleton is linked via MreC and MreD to the PBP murein biosynthetic enzymes.
MreC is shown as a transmembrane protein, but it may be a periplasmic.

This multiprotein structure may permit the MreB cytoskeleton to regulate the pattern of cell wall biosynthesis by providing spatial information to the murein biosynthetic machinery.



OM, outer membrane;
PG, peptidoglycan (murein);
IM, inner membrane

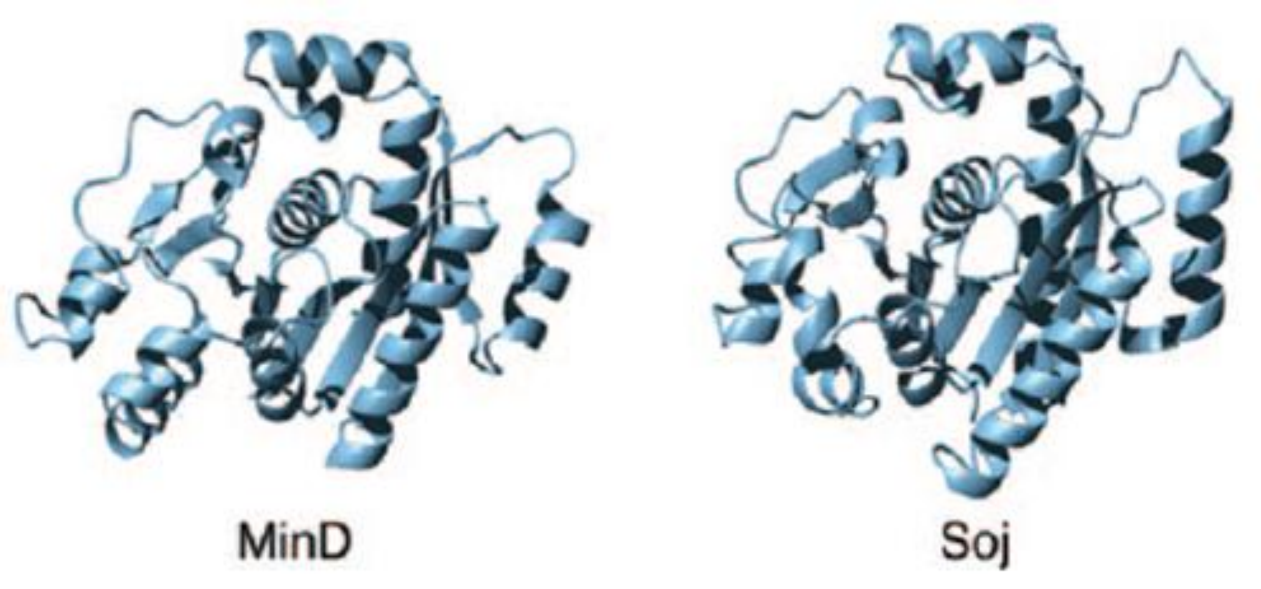
Прокариотические гомологи тубулина



From left to right:

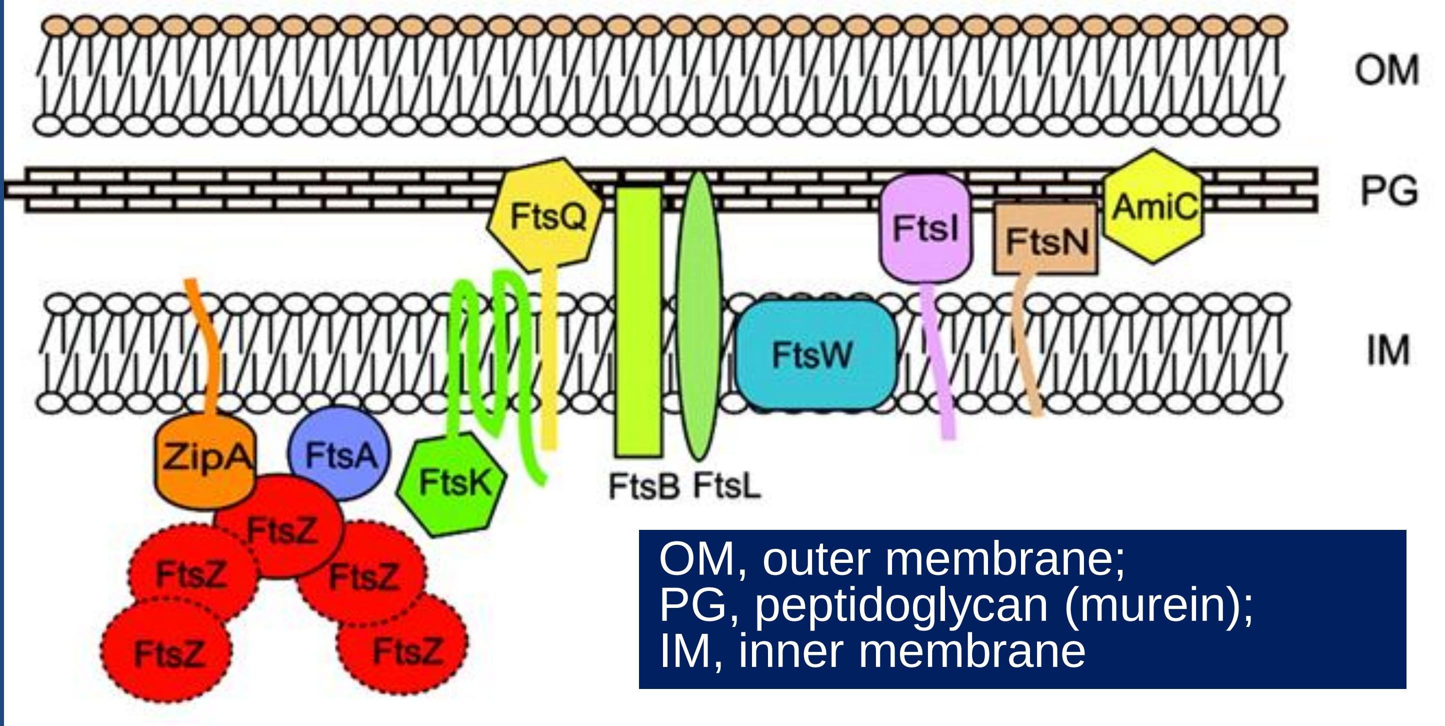
- *Bos taurus* ß-tubulin, GTP/GDP bound
- *Methanococcus jannaschii* FtsZ , GDP bound
- *Prosthecobacter dejongeii* BtubA, GTP bound

Прокариотические филамент-образующие белки



MinD (left) and Soj (right) proteins:
- *Archaeoglobus fulgidus* MinD, nucleotide free
- *Thermus thermophilus* Soj, ADP bound

Diagrammatic representation of a portion of the cytokinetic ring (septasome) of *E. Coli*

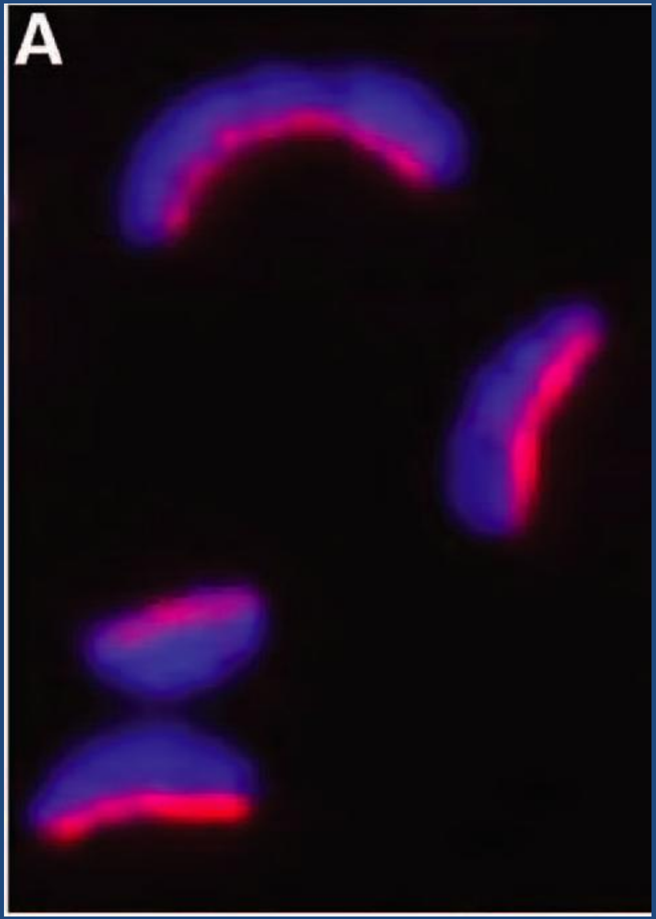


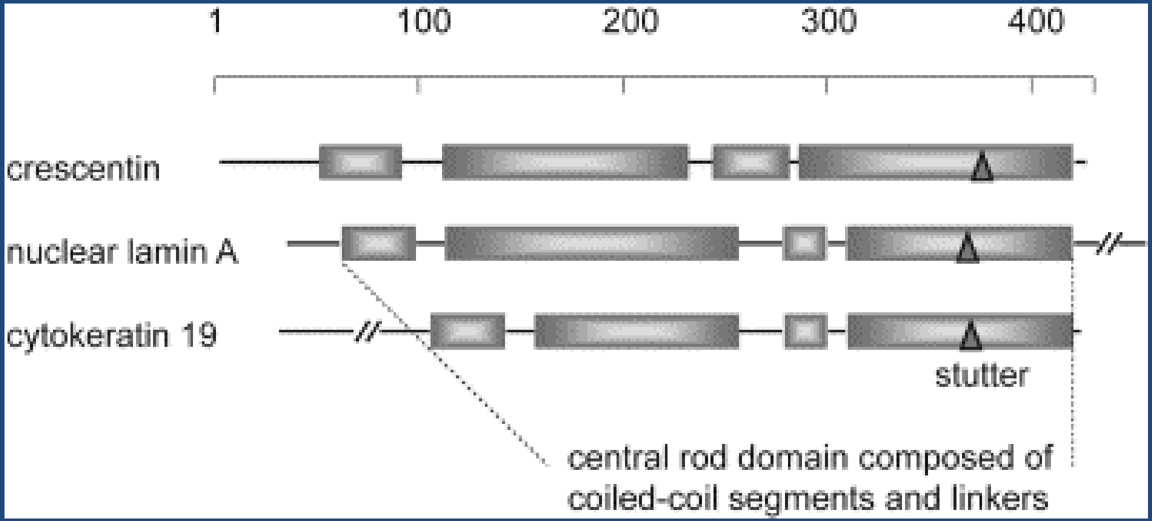
OM, outer membrane;
PG, peptidoglycan (murein);
IM, inner membrane

.

FtsZ is anchored to the cell membrane by FtsA and ZipA, and the other septasomal proteins are then added to the complex.

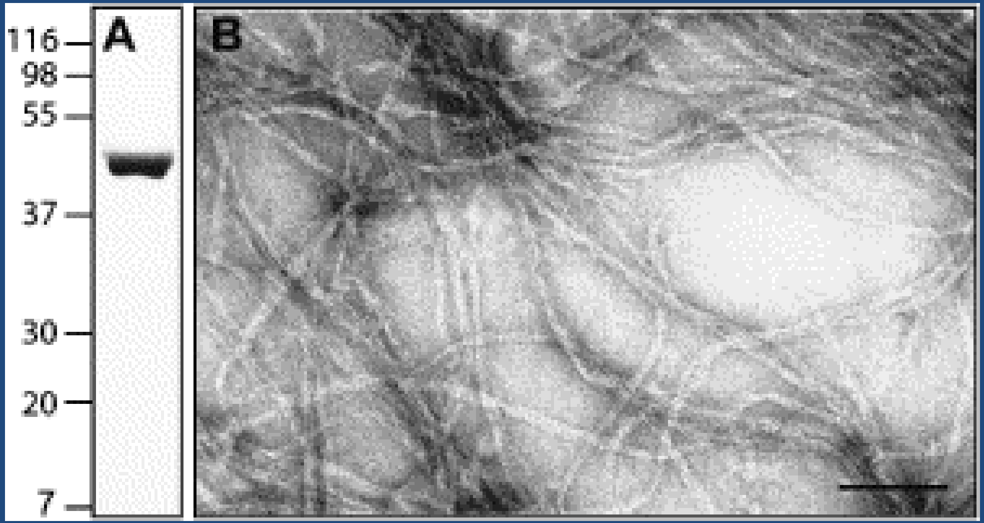
«Промежуточные филаменты» у *Caulobacter crescentus*



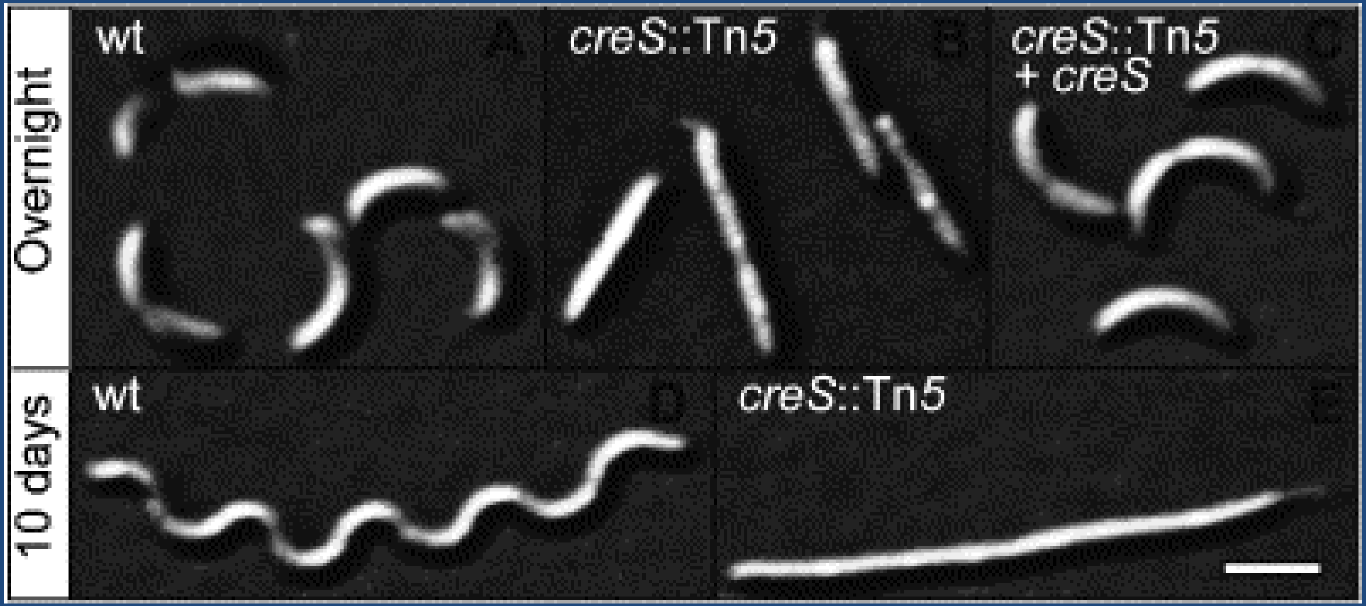

1
100
200
300
400
crescentin
nuclear lamin A
cytokeratin 19
stutter
central rod domain composed of coiled-coil segments and linkers

The Bacterial Cytoskeleton: An Intermediate Filament-Like Function in Cell Shape.
N.Ausmees, J.R. Kuhn and C.Jacobs-Wagner.

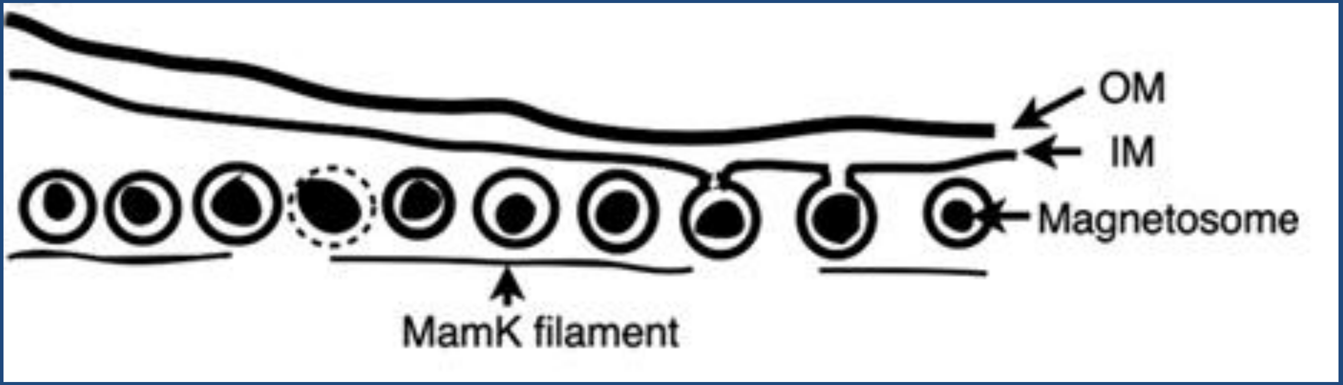
Cell, 115, 705-713 (2003)



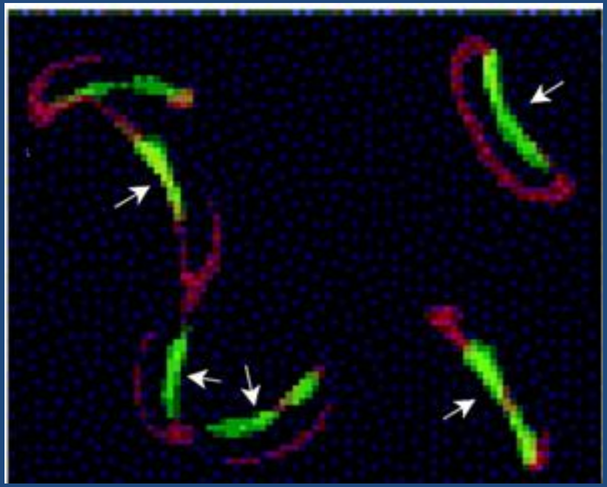
cresentin filaments made in vitro



morphology of *creS* (crescentin) mutant

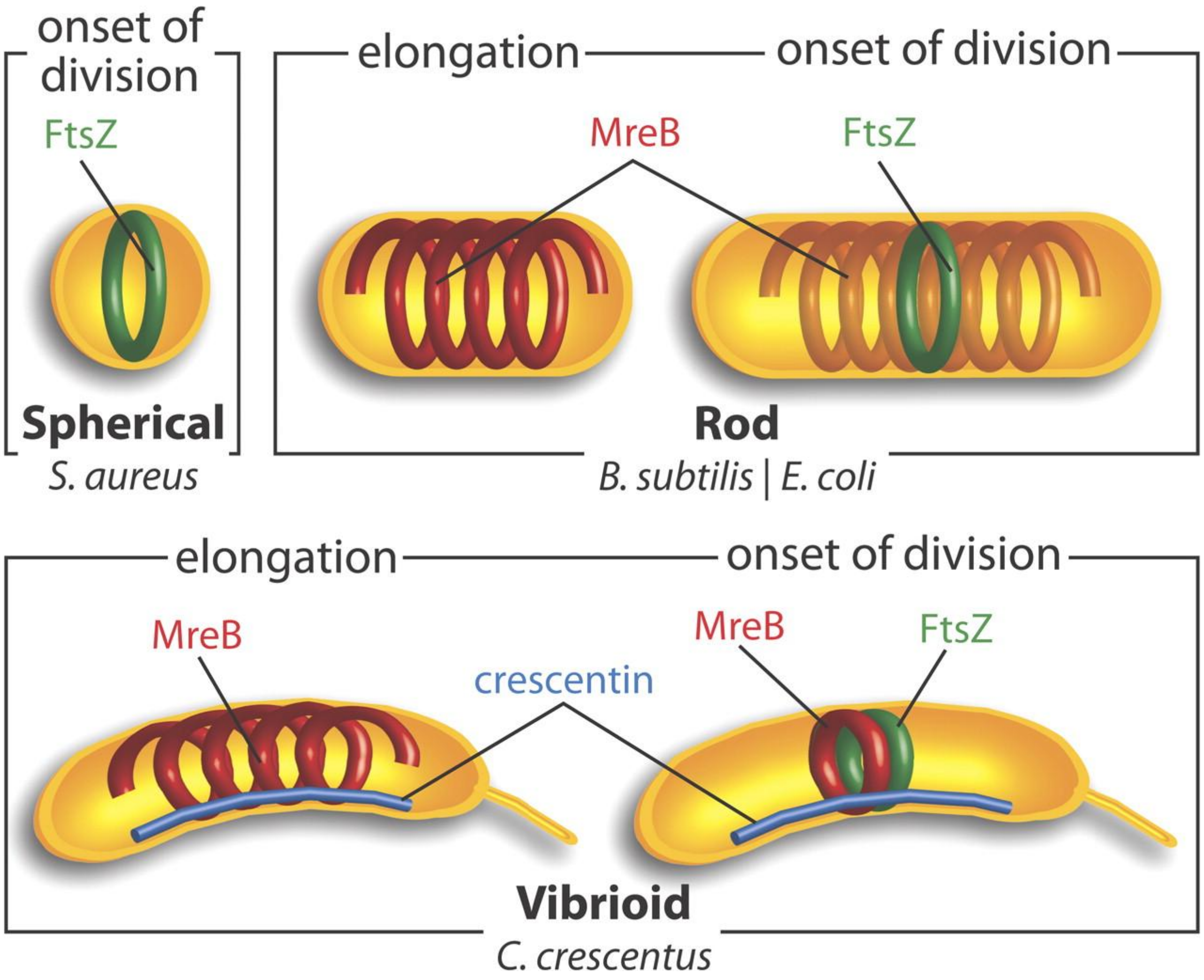


Magnetosomes located under the surface of the cytoplasmic membrane of *Magnetospirillum magneticum*



The intermediate filament-like protein crescentin (green) forms filamentous structures (white arrows) along the concave edge of *C. crescentus*. Membranes in red

Участие актин- и тубулин-подобных белков в делении бактерий



Cabeen, Jacobs-Wagner J. Cell Biol. 2008:179:381-387

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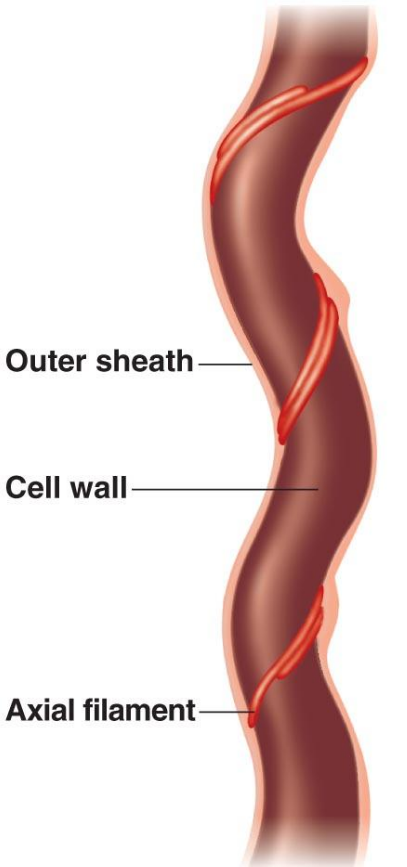
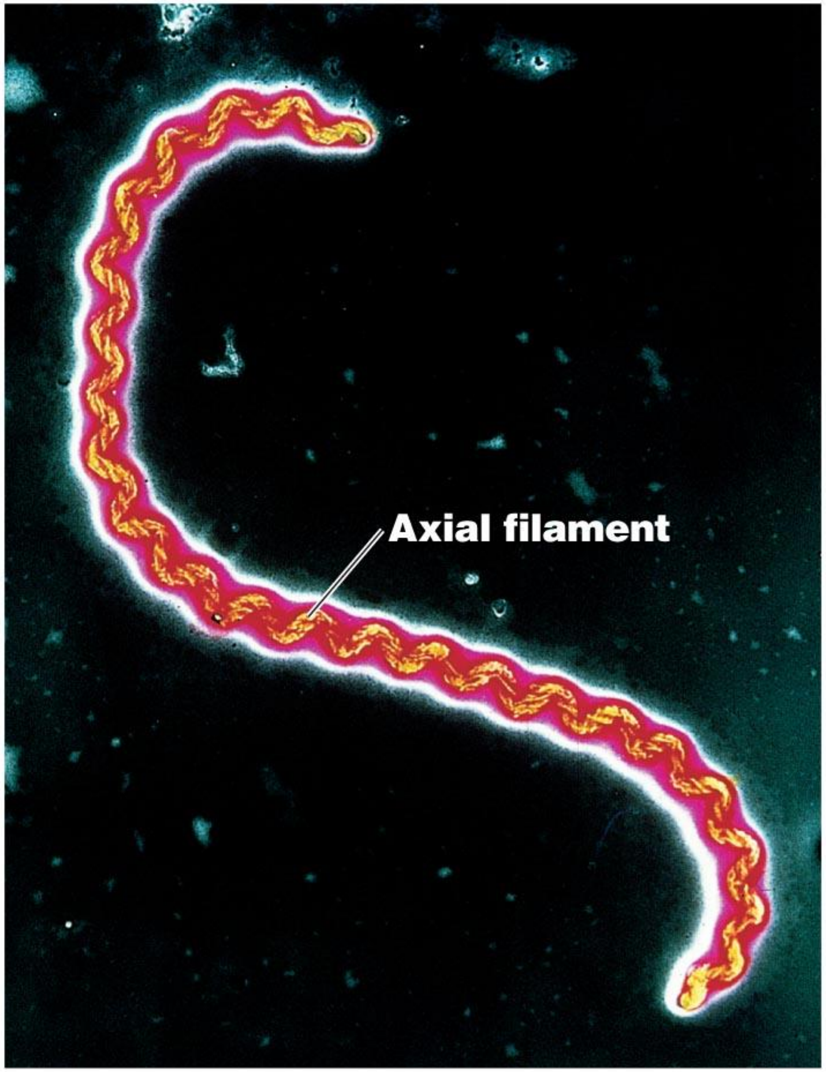
JCB

Axial Filaments

- Also called **endoflagella**
- In spirochetes
- Anchored at one end of a cell
- Rotation causes cell to move





(a) A photomicrograph of the spirochete *Leptospira*, showing an axial filament